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SCIENTIFIC & TECHNICAL PAPERS

OF

WERNER VON SIEMENS.

VOL. II.

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WERNER VON SIEMENS.

TRANSLATED FROM

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VOL. II.

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PREFACE.

THIS Second Volume of the Translation is based, like the First, on the Second German Edition. It contains the technical papers contributed by Dr. WERNER VON SIEMENS to various learned societies, and descriptions of new inventions and apparatus; many of these take the form of the specifications filed with the applications for the grant of patents.

CONTENTS OF VOLUME II.

THE SCIENTIFIC PAPERS & ADDRESSES OF WERNER VON SIEMENS.

PRUSSIAN PATENT FOR A PROCESS OF DISSOLVING GOLD BY MEANS OF THE GALVANIC CURRENT FOR GILDING BY THE WET METHOD.*

THE description of the patent granted for five years throughout the Prussian states to Second Lieutenant Werner Siemens on the 29th March, 1842, for a process of dissolving gold by means of the galvanic current for gilding by the wet method, cannot now be traced in the records of the former technical department. The application for a patent contained a description of electro-gilding and electro-plating by the use of certain gold and silver salts, among which the cyanides of gold and of silver and the hyposulphites of gold and silver were specially mentioned.

The patent was only granted for the use of hyposulphites of gold and of silver, as an English patent of Elkington already existed, which claimed the cyanide compounds.

* 29th March, 1842.

DESCRIPTION OF THE DIFFERENTIAL GOVERNOR OF THE BROTHERS WERNER AND WILLIAM SIEMENS.*

THE need of a governor capable of regulating the speed of steam-engines and water-engines more perfectly than has hitherto been possible, has made itself felt for some time past, as is proved by the numerous attempts which have been made to improve the centrifugal governor hitherto almost exclusively used, or to effect the regulation by other means. Practice has hitherto decided on the retention of the centrifugal governor, as it excelled the new forms both in sensitiveness and also to a great extent in simplicity and durability. As our governor, founded on a new principle, has already been frequently tested with extremely favourable results, we shall not refrain longer from publishing an account of it.

We too use the conical or centrifugal pendulum for regulation, but in quite a different way from the centrifugal governor, in which the rotation of the double pendulum is wholly dependent on the speed of the engine. If the speed of the engine varies and the governor in consequence revolves more quickly or more slowly, the pendulums assume a greater or less height of rotation, depending on the altered velocity of rotation, and modify the speed of the engine by this altered position. Our simple or double conical pendulum on the contrary moves freely and quite independently of the speed of the engine in smaller and therefore more isochronous revolutions.

Therefore if from any cause the existing normal proportion between the driving power and load of the engine is changed, and in consequence it begins to move more quickly or more slowly, the free swinging pendulum, which retains its original velocity, must either lag behind or gain. In our governor the regulation of the speed of the engine is made to depend on the diversity of the travel of the engine and governor in equal times, or rather on the difference of the two. We think, therefore, that we may aptly call it a differential governor, to distinguish it from the

* Dingler's Polyt. Journal, 1845, Vol. XCVIII. p. 81.

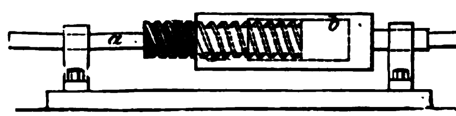
centrifugal governor, which is dependent on centrifugal force. Our constructions of regulators, based on the above-mentioned general principle, are nevertheless essentially different in the mechanical means by which the difference of the travel of the engine and governor in equal times is changed into an independent motion, and hence made applicable for the regulation of the motive power. In order to effect this, the velocity of rotation of the engine and of the governor must be so combined mechanically that equal velocities of both entirely annul one another so far as the production of a third motion is concerned, and that this last, when it does occur, is only dependent on the difference of the motion of the two former.

We obtain this generally in three different ways, viz. :—

1. By a combination of male and female screws.
2. By the combination of a toothed wheel with a so-called endless screw, movable in its bearings, and
3. By means of three wheels gearing into one another.

1. *By the Combination of a Male and Female Screw.*—The engine turns a screw *a* (Fig. 1) which can slide in its bearings.

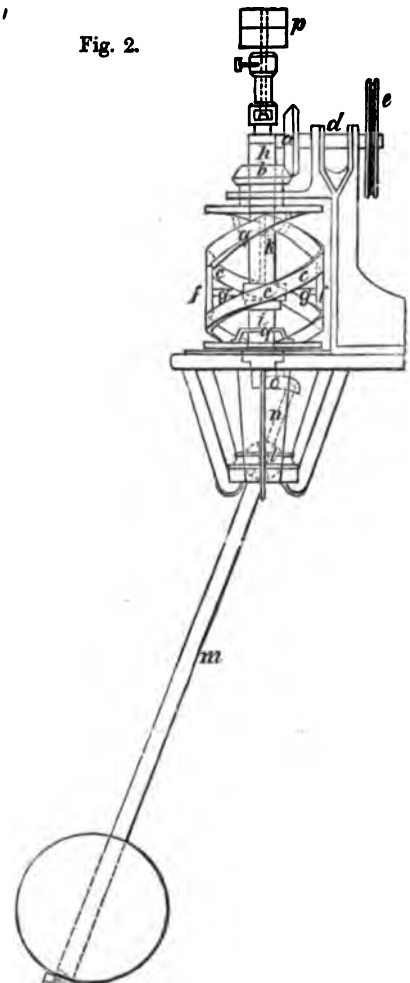
Fig. 1.



The corresponding female screw *b* is turned in the same direction with a constant velocity by the action of the governor. If the speed of the engine agrees perfectly with that of the governor, the two screws will make the same number of revolutions in the same time. No shifting of the screw in its bearings will, therefore, take place. This will, however, occur if the speed of the engine alters, and in consequence one screw will revolve within the other, and this revolution will continue until the variation in the speed of the engine is again fully balanced by the increase or diminution of the motive power, which is made to depend on the travel of the screw barrel

When both screws revolve uniformly again they remain in the position relatively to one another which they had at the moment

Fig. 2.



that this took place, and until a new disturbance in the speed of the engine occurs.

In order to avoid the considerable friction which opposes the

revolution of one screw in the other, and at the same time to avoid the special mechanism which would be necessary to maintain the pendulum in motion, we replace the female screw by a double screw-shaped path and the male screw by a perpendicular axle having horizontal arms placed within the former, on which two friction rollers are fitted, which roll up and down on the above-mentioned spiral-shaped paths. Such a governor is shown in Fig. 2.

The two spirals *c c* are rotated by the conical wheels *a* and *b* by means of a collar. This is worked from the engine either by means of a pulley *e*, or by a train of wheels. The two friction rollers *f*, which are fixed on the two ends of the common axle *g*, run on the two spirals. This axle is connected with the hollow cylinder *h*, which, therefore, rises or sinks when the friction-wheels roll up or down. The axle *i* inside the hollow cylinder is rotated by the pendulum, and is provided with two pins *k*, which engage in two opposite grooves in the interior of the hollow cylinder. The friction opposed to the up and down motion of the hollow cylinder is reduced as much as possible by small friction rollers, with which these pins are provided. The revolution of the hollow cylinder thus depends on the axle *i*, and consequently on the pendulum. The connection of the two latter is so arranged that the conical pendulum *m*, which is suspended by the ball joint *l*, is extended upwards beyond the point of suspension. The point *n* of this extension of the pendulum rod, therefore, describes a circle, when the pendulum is in motion. It engages in a circular groove curved downwards in the metal piece *o*, fixed to the lower end of the axle *i*. The motion of the axle is, therefore, dependent on that of the pendulum, whilst this latter is free to swing in greater or smaller circles. The series of actions of the whole mechanism will now be easily understood. The friction rollers are pressed down by the weight of the hollow cylinder *h*, and thus tend to roll down the paths. But as this can only happen according to the rotation of the pendulum, this uniform force, which is, if necessary, increased by weights *p*, maintains the pendulum in uniform oscillation. If the engine stand still, and the pendulum alone be set in motion, the friction rollers would have rolled down the whole length of the spirals, when the pendulum had completed two-

fifths of a revolution. If now the opposite suddenly took place, *i.e.*, if the pendulum stood still, and the engine had its normal velocity, the friction rollers would roll up again in the same time. If, therefore, engine and pendulum move at the same time and synchronously, the wheels are raised just as much by the former, as the latter allows them to fall in the same interval of time. They must, therefore, remain just as they were when the motion of both became uniform. If the engine from any cause begins to go more quickly, the spirals will revolve more quickly in the same proportion. The friction rollers must, therefore, commence an ascending motion. If the motive power is now diminished by the upward motion of the hollow cylinder connected with it, for instance, if the steam valve is closed, this motion continues until equilibrium between motive power and load has been again fully established, and the engine has again resumed its normal speed.

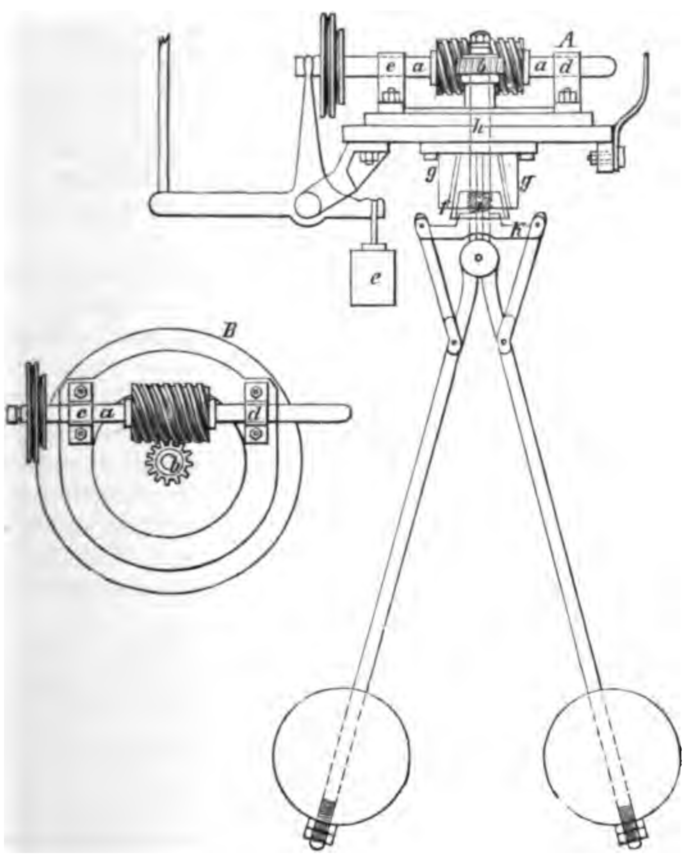
In order that no violent action on the pendulum may take place when the engine is started, and when extraordinary disturbances in its speed occur, it is arranged that when the friction rollers have arrived at the upper or lower limit of their travel, the friction rollers fixed on the pins of the axle then come out of the grooves in the interior of the hollow cylinder. By this means the connection between this latter and the axle *i* is interrupted, and both can now revolve independently of one another. When the abnormal velocity of motion of the engine has been checked by the complete closing or opening of the steam valve corresponding to this position of the friction rollers, the friction rollers fall back into the next pair of grooves of the hollow cylinder.

This is effected merely by the weight of the latter when at its highest point, but on the contrary by a spring *q* when at its lowest point. In order that it may not be necessary to set the pendulum swinging by hand when the engine is started the groove in the metal piece *o* is made only so long that the pendulum when at rest is still a few degrees out of the perpendicular. The amplitude of the pendulum can be arranged as desired by means of the weight *p* as the frictional and air resistance increases with it, but the force moving the pendulum remains unaltered. The amplitude must, therefore, always return

to its normal amount, after it has been somewhat increased or reduced for a time by the governor having to give off power.

2. *By a Combination of a Toothed Wheel and Endless Screw.*— The screw *a*, capable of sliding in its bearings *c* and *d* (Fig. 3),

Fig. 3.



is turned by the engine by means of a cord or wheel connection. It gears into the little toothed wheel *b*, which is turned by the pendulum. The latter may either be a simple pendulum, as in Fig. 2, or a double one, as here assumed. With normal speed of the engine, the screw must be turned so quickly that it would

rotate the wheel *b* once if it were loose, in the same time that the pendulum makes one swing. Then if *b* is connected with the pendulum, it will screw as quickly on the wheel towards *c*, as that would be pushed towards *d*, if it did not turn. It must, therefore, with this normal speed of the engine, maintain its position unaltered. A weight *e* tends always to shift it towards *d*. The grip in the teeth of the wheel *b* is opposed to this, through which wheel this force is transferred to the pendulum, which is thus maintained in motion. If the engine changes its normal speed, and if the screw in consequence revolves more quickly or more slowly, it must move forward in the one or other direction, until, by the resulting change in the position of the steam valve, each change of motion is again annulled and the speed of the engine therefore again perfectly regulated.

As with a double pendulum not much more force is necessary to swing it in larger amplitudes, a contrivance is necessary in order to maintain this by which a resistance against the revolution, increasing with the amplitude, is set up as constant as possible. This is here so arranged that the cone *f*, covered with leather, is pressed with a force increasing with the amplitude against the fixed hollow cone *g*. The cone *f* is movable along the axle of the pendulum, and its pressure against the hollow cone, and consequently also the frictional resistance, is dependent on the total pressure of the spring *i*, through the metal piece *h*. The frictional resistance, therefore, increases with the amplitude.

3. *By three wheels gearing into each other.*—If one wheel is turned by the engine and another by the governor in the opposite direction and with the same circumferential velocity, then a third wheel gearing into both is turned by them uniformly around its axis without any effort being imparted to it to move forward in the direction of the motion of one of the wheels. As soon, however, as a change of motion takes place, the connecting wheel must quit its place, and roll forward in the direction of the motion of the wheel which revolves more quickly. This can be effected :

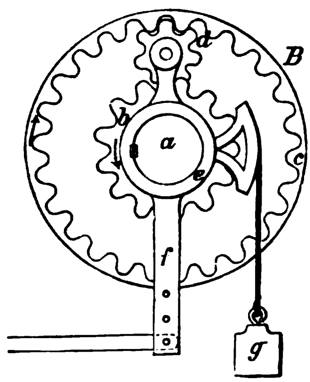
A. By spur-wheels :

A toothed wheel *b* is fixed on the main axle *a* of the engine

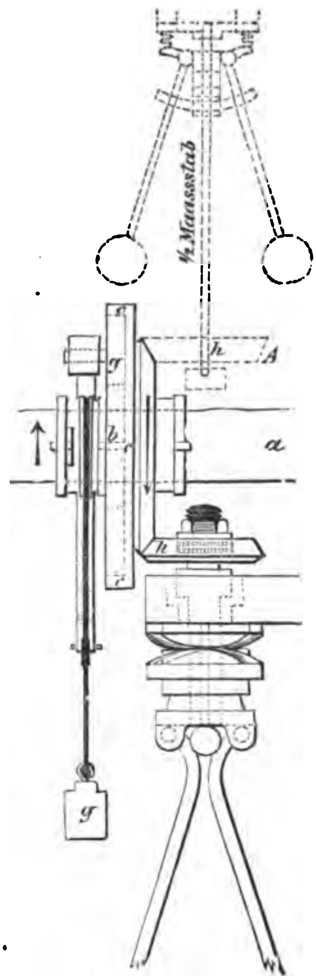
(Fig. 4) or on another rotated by means of it. The loose wheel *c* fitted on the same axle having teeth inside is revolved by the

Fig. 4.

A.



B.



governor. The pinion *d* gears into both, the axle of which is in connection with the collar *e*, also placed loosely on the axle. This collar is provided with the lever *f*, by which the steam valve is moved. If the wheels *b* and *c* are turned in opposite directions with the same circumferential velocity, the pinion, and with it the collar *e* and the lever *f*, maintain their positions unaltered. But if the speed of the engine alters, the pinion must roll forward in the direction of the more quickly moving wheel. The collar *e* will then be turned until, by the motion of the lever *f* connected with it, the equilibrium between motive power and load, which has been disturbed, is again perfectly reproduced. The weight *g* always tends to turn the

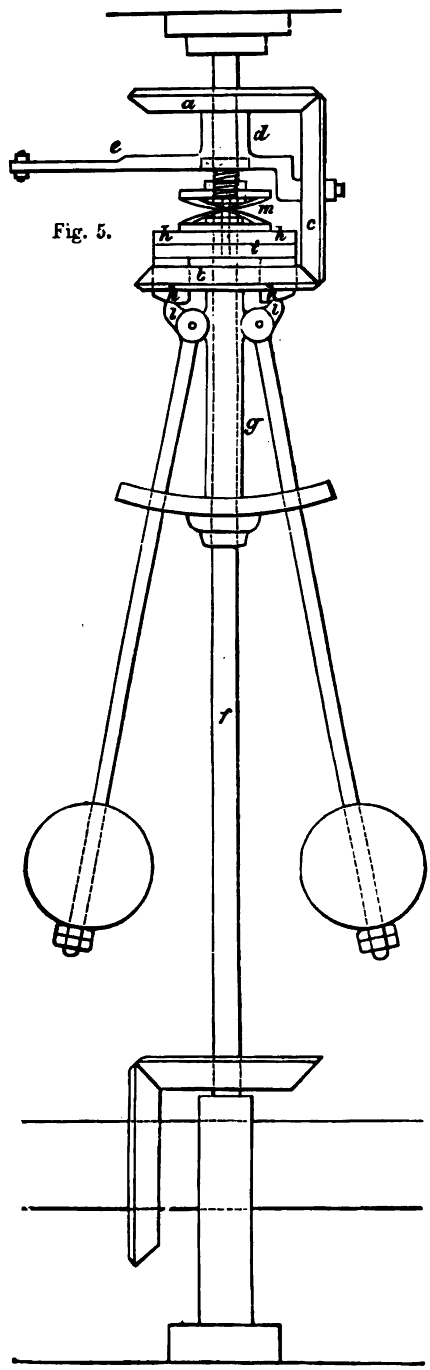


Fig. 5.

collar *e* in the direction of the wheel turned by the pendulum. This force is transferred to the wheels *b* and *c* by means of the teeth of the pinion, and the pendulum thus kept in motion. In order that on starting and stopping the engine there may be no violent action on the double pendulum, which is here provided with one of the above described friction arrangements, the conical wheel *h* is connected with the pendulum axis by friction.

B. By conical wheels :

Two wheels *a* and *b* (Fig. 5), placed opposite to one another on the same axis, are revolved in opposite directions with equal velocities; one by the engine and the other by the pendulum. The conical wheel *c*, which is connected with the loose collar *d* and the lever *e* fixed to it, gears into both. By means of a weight fixed anywhere the lever *e* is drawn back and the pendulum thereby kept in motion. In the arrangement here shown the axis *f* of the pendulum, together with the conical wheel *a*, is driven by the engine in the ordinary way. The double pendulum hangs from the sleeve *g*, to which also the conical wheel *b* is fixed. The pendulum, therefore, turns in the opposite direction to its axis. In order to give the pendulum as constant an amplitude as possible, a variable frictional resistance is employed here also. The disc *h* is pressed down by a spring *m*. It is turned by a groove and feather from the pendulum axis and lies on the ring *i*, which is turned by the conical wheel *b* in the opposite direction. This is effected by means of two lugs *k*, which protrude from the ring and through the conical wheel. Two projections *l* connected to the pendulum bars press against these lugs. If the pendulums make larger oscillations, the ring *i* and the disc lying on it are raised, and the spring *m* is compressed. The disc and ring are thus pressed together with much more force, and the friction is increased in the same proportion.

As all the modifications of our governor which have been described depend on the same principle, viz., differential motion, they all work equally well, if only back lash is avoided as much as possible, and the weight and length of the pendulum is made to correspond to the force necessary for the regulation of the speed of the engine. The proportions of the pendulum must be farther adjusted to the sensitiveness of the governor. The

shorter the time in which it completes its action, and, therefore, the greater its sensitiveness, the shorter and lighter can the pendulum be made. Yet the increase of its sensitiveness is limited by the unavoidable back lash in the governor, and the irregularities proper to the motion of the engine, which should not exert too great an influence on its play. Hence the more regularly the engine runs, and the less the back lash in the governor, the more sensitive and the lighter can the latter be made. In the case of good engines with adequately heavy fly-wheels, a governor of this construction seems the most advantageous with which the total closing of the throttle-valve is effected by one-fifteenth or even one-thirtieth of a revolution of the engine, if the valve was at first wide open, and the pendulum at rest. Under more unfavourable conditions the sensitiveness of the governor must be made considerably less, but a certain limit cannot be exceeded, as otherwise periodical fluctuations in the stroke of the engine must occur.

With the centrifugal governor an acceleration of the speed of the engine by one-twentieth of a revolution cannot be indicated, because the centrifugal force of the balls is not sufficiently increased by this slight increase in the velocity of revolution to overcome the resistance opposed to their flying out. The differential governor has completed its full action, and again completely regulated the speed of the engine, before the centrifugal governor has even begun to move.

Experience proved this absolutely in an engine simultaneously fitted with a differential and centrifugal governor. The latter did not move even with the greatest alterations in the load. There is, moreover, this great difference between the performance of the two governors, viz., a centrifugal governor can only alter but cannot completely stop the existing difference of motion of the engine, the differential governor absolutely compels it to take up again the speed determined on. As this happens in the very first moments of the change in velocity which takes place, the fluctuations in the speed of the engine, which must necessarily occur, become imperceptibly small, and the back fluctuations, which, according to theory, must occur in the differential governor also, are no longer perceptible even in the governor itself, since they lie within the limit of the unavoidable back lash. With

our governor we can further overcome considerable resistances, if this only takes place sufficiently quickly and the single or double pendulum is long and heavy enough. It hence serves for regulating the speed of water-engines and even wind-mills.

We employ as a rule, in cases where considerable force is necessary, as, for instance, when the regulation of the steam-engine has to be effected by an alteration in the rate of expansion of the steam, a double pendulum with variable friction, but in those cases where the force is very small, as, for instance, when an easily turned steam valve has to be moved, a simple pendulum swinging in a ball joint. In this, as experience has shown, there is no wear of the ball joint if only it is sufficiently protected from dust. With a governor in constant use for six months, the ball joint was not worn in its cast-iron bearing, but only polished in some places. With the double pendulum the friction resisting the flying apart of the balls must be reduced as much as possible, as otherwise the mean speed of the engine does not remain constant, The question as to which of the various forms of governor is most suitable cannot receive a general answer. For the engine builder this great variety in its form is very desirable, for it permits him in designing the engine to deal freely with the space available, and to put the governor where he can most conveniently find room for it.

APPLICATION FOR A PATENT FOR A NEW KIND OF ELECTRIC TELEGRAPH AND COMBINED ARRANGEMENT FOR PRINTING MESSAGES.*

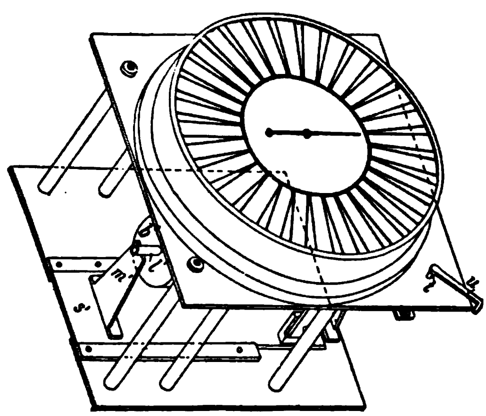
ALL the telegraphs hitherto used depend on the dynamical action of the galvanic current, and the signals are communicated by a determined series of short currents following one another more or less quickly. The telegraph apparatus hitherto known differ essentially from one another in the application of the electro-magnetic force of the circuit of the electric battery (which has been almost exclusively used on account of its more intense action); in

* 1st May, 1847.

all, however, the sequence of making and breaking the working current is arbitrary, and is effected either by hand or by special clockwork driven either by a weight or spring. The dynamical action of the current is, however, dependent on its strength; therefore, the velocity with which the makes and breaks follow one another must depend on it if the speed of signalling is to be made as rapid as possible, and the danger is not to be risked of exceeding the limit of the interval necessary for the completion of the desired motion, and so to disturb the synchronous movement of the apparatus in circuit. In the electro-magnetic telegraphs almost exclusively used in recent times there are, however, other and more considerable inconveniences connected with this independent or arbitrary change of current, the existence of which has hitherto led to a certain amount of insecurity in them. The magnetism is only developed gradually in the soft iron core of electro-magnets and completely only after a certain interval of time. Yet more important is the time necessary for the disappearance of the magnetism after the current is interrupted. Were it always necessary to wait until the magnetism had been completely developed the action of the apparatus would be too slow. If the breaks were allowed to follow one another more quickly there is evidently much more danger of dropping an individual signal if the speed of the reversals of the current and its strength are not always constant, both of which, as is known, cannot be attained. These drawbacks are, moreover, intensified by the fact that, even after the final interruption of the current, the magnetic attraction of the iron cores continues to a certain extent, which is approximately proportional to the previous attractive force. This remanent attractive force may easily become so considerable with an increased current, or with an increased duration of working, that the armature will no longer fall away, and consequently the working of one or all the instruments in circuit will cease entirely. I have succeeded in completely removing these inconveniences of electro-magnetic telegraphs by effecting the breaking and making of the current by means of the apparatus itself, which makes the velocity of the reversals dependent only on the strength of the current and the magnitude of the resistance to be overcome. This is effected (as in the case of steam-engines with spring slide valves) by a movable lever or slide being moved at

the last moment of the motion of the oscillating part of the apparatus, and in this way the closing contact of the conducting wire is alternately made and broken. If, therefore, two or more such apparatus are joined up in the same circuit, the current cannot circulate until both or all the slides have made contact. If the instruments consequently work individually at different speeds, they must yet advance synchronously when connected up in the same circuit, for the quicker going apparatus must wait before each new impulse for the making of the contact by the slide of the most slowly moving apparatus, consequently the commence-

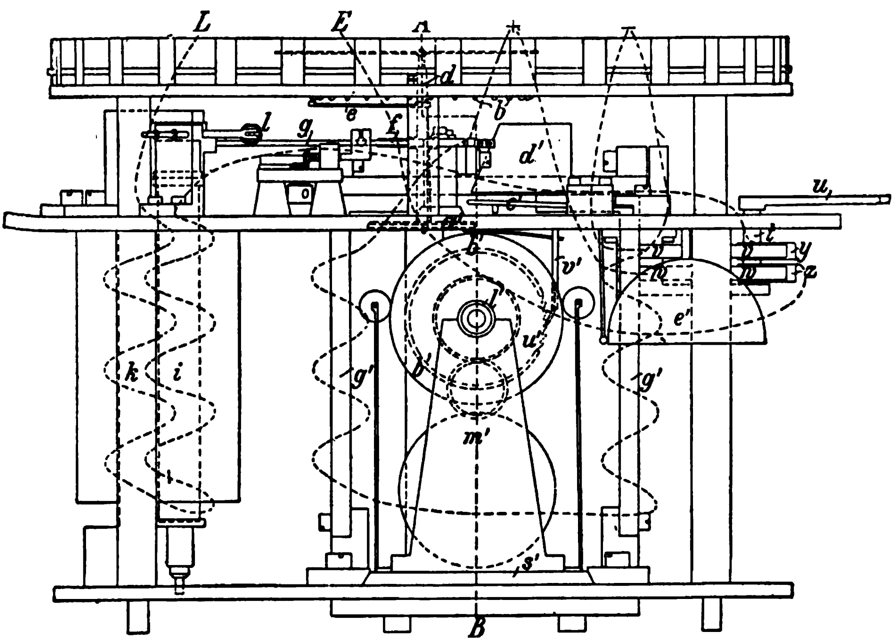
Fig. 6.



ment of all fresh impulses always coincides in all the instruments. As, in this way, each apparatus interrupts the current at the moment in which the magnetism of its electro-magnet has finished the work it has to do, the magnetism can never increase beyond this point, as it may with arbitrary interruption, when this takes place too slowly. Therefore, with the greatest difference in the intensity of the current employed, there can be no danger of the interruption of the uniform advance of the apparatus if the intensity is only great enough to move it forward at all. This was fully confirmed in practice, for the first two telegraphs, with automatic current-breakers, which I have had made by Messrs. Boettcher and Halske, mechanicians, supported a sudden increase of about six times the original strength of current without their regular

action being disturbed. This automatic regulation of the current, which I look upon as my invention in so far as it is applicable to oscillatory electro-magnetic apparatus, and especially to electric telegraphs, and is workable by means of a movable piece of metal, is susceptible of the most varied arrangement and application, and can be applied to all present systems of needle and printing telegraphs instead of the current-breakers employed in them.

Fig. 7.



As an example, a printing telegraph is shown in the following figures, which has been constructed of double the size shown in Figs. 7 and 9, and is already in use.

Fig. 6 gives a perspective view of the complete apparatus, without the base plate into which the lower part is fixed.

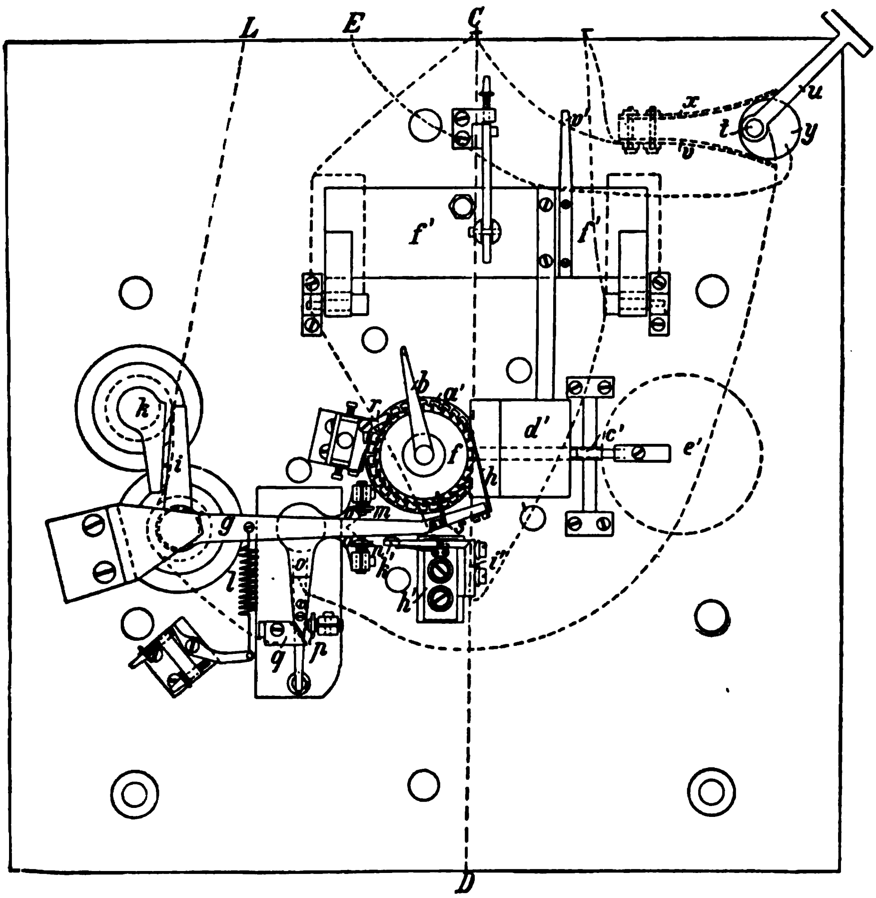
Fig. 7, an elevation, with the ring surrounding the upper portion, and the base plate, removed.

Fig. 8, a plan, with the upper plate, letter plate and key removed.

Fig. 9, a vertical section on line C D of the plan, and A B of the elevation.

Fig. 10, a detail drawing of the rotating axle with the portions fixed to it.

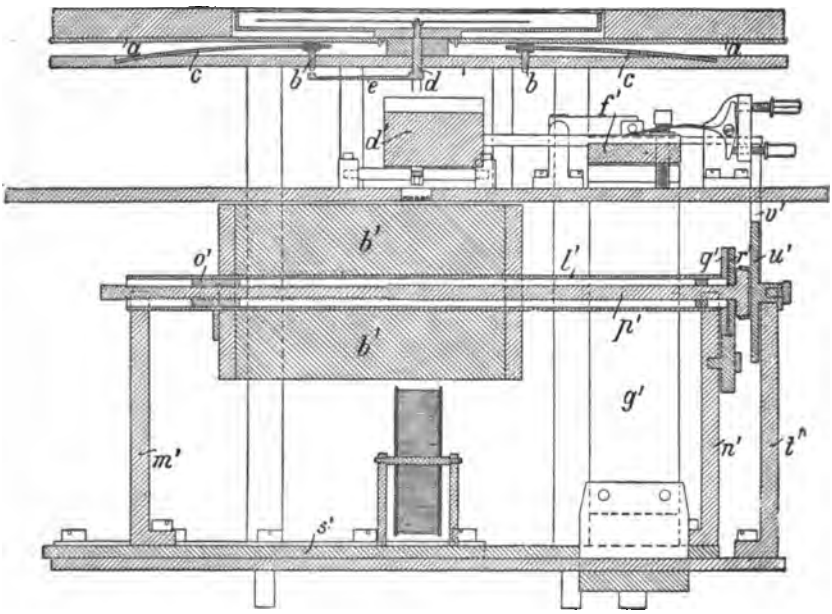
Fig. 8.



The frame consists of three horizontal plates connected by means of columns. On the upper plate, equally spaced around the circle, are 30 keys (Fig. 6) similar to pianoforte keys, which are marked with letters or numbers. They surround the dial plate,

over which a pointer works under a thick glass plate. Fig. 9 gives a section through the centre of the upper plate, with the keys lying upon it. Each key consists of a metal piece, *a*, covered with wood and ivory, which lies on the head of a pin, *b*. These pins pass through 30 holes bored in the upper plate at equal distances apart and from the centre, and are movable in them.

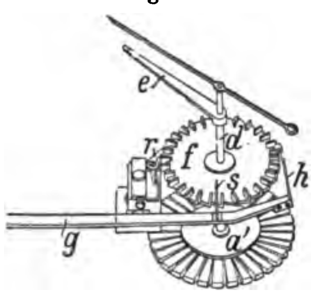
Fig. 9.



Each pin, with the key resting on it, is raised by means of a spring, *c*, when there is no finger-pressure upon it. A vertical axis, *d*, passes through the centre of the upper round plate. This carries on its upper end the pointer already mentioned, also immediately under the plate an arm, *e*, the end of which is curved upwards and cut obliquely and passes close under the pins cut obliquely to correspond. If a key is pressed down the pin belonging to it is depressed so far below the upper plate that the end of the arm strikes against it, and the further rotation of the axis is thus prevented. The wheel, *f*, is also carried by the axis, *d*, which

has its lower bearing in the middle horizontal plate. This wheel has 30 teeth, and is so cut, that in the plan (Fig. 8) it is a ratchet, and in the side view (Fig. 10) it is a crown wheel with small upright teeth. The forward motion of the wheel, with the axle, is effected by the oscillatory motion of the horizontal lever, *g*, to the end of which a spring, *h*, is fixed, which forms a hook at the end catching in the teeth of the tread wheel, *f*. This lever is fixed on the axle of a revolvable horseshoe magnet, *i* (Figs. 7, 8), the short unwound legs of which are attracted by the legs of a second electro-magnet, *k*, quite similar but fixed, when the wire surrounding both magnets is traversed by an electric current.

Fig. 10.



The convolutions of the revolvable magnet, *i*, are wound round a split brass cylinder, which is fixed, and closely surrounds the armature without touching it. This possesses the advantage that the mass of the surrounding wire does not take part in the movement, and consequently the moment of inertia of the oscillating magnet is considerably diminished. The spiral spring, *l*, acting on the lever, *g*, opposes the reciprocal attraction of the magnet, and therefore turns back the magnet, *i*, with the lever, *g*, when the current which effects a motion in the opposite direction is interrupted. This to-and-fro motion of the lever, *g*, is limited and at the same time produced by its striking on the two stops, *m* and *n*. These are fixed on the short leg of a bent lever, *o*, which can revolve around a vertical pin. Its rotation is, however, kept within very narrow limits by a similar fixed stop, *p*, against which its second longer leg strikes when the lever, *g*, strikes the stop, *m*, and by the insulated metal piece, *q*, which limits the rotation of the bent lever in the opposite direction, when the lever, *g*, is

thrown against the stop, *n*, by the force of the spiral spring. The points of contact of the insulated metal piece, *q*, and of the long arm of the bent lever, *o*, are plated with gold or platinum to present a non-oxidizable contact. The contact surfaces are cut obliquely in such a way that the end of the bent lever, *o*, slides a little along the metal piece, *q*, owing to its elasticity. In this way the contact surfaces are always kept clean and continuity of contact ensured by obviating the back lash. For this purpose an additional spring is fixed to the bent lever, which slides on an adjustable stone, and by its friction thus assures both the contact and its breaking. If now the metal pieces, *o* and *q*, and the coils of the magnets are joined up in the circuit of a battery, the current can only circulate so long as the contact between *o* and *q* continues, which, as explained above, is established by the action of the spring, *l*. The magnets are energized by the current now circulating; the lever, *g*, moves against the pull of the spring until it strikes the stop, *m*, by which further motion in this direction is arrested and the contact simultaneously broken. The spring, *l*, to the influence of which alone the lever, *g*, and the revolvable magnet are now left, now moves them back, again makes contact, and thus brings about a new impetus, etc. At each oscillation the hook of the style, *h*, placed at the end of the lever, *g*, draws the step wheel a tooth farther forward. To secure this intermittent forward motion of the wheel a pawl, *r*, is fixed (Fig. 10), which prevents any back lash, and further, a steel piece, *s*, hooked beneath, is fixed to the lever, *g*, and engages between the vertical teeth of the wheel to prevent its flying back after the completion of the impulse. If now the arm, *e*, placed on the axis of the wheel, is so arranged that it strikes on the depressed pin before the lever, *g*, strikes the stone, *n*, therefore before the completion of the backward impulse, this can be no longer completed, since the hook of the style is held fast by the arm of the wheel. The contact is not, therefore, re-established, and the remaining apparatus in circuit must equally remain at rest, for no new current enters. If the wheel is, however, freed by the release of the key, the lever, *g*, completes its backward impulse, the missing contact is made, and the motion of the apparatus begins anew, and continues until again broken by the pressing down of another key when the pointer reaches it.

As is clear from the above, the operation of telegraphing with my telegraph consists simply in depressing successively the keys marked with the signs to be transmitted until the pointer reaches them and the motion is stopped. If no key is depressed the apparatus continues in motion so long as a working battery is inserted at any point in the circuit.

The speed of the motion is dependent on the strength of the battery, and it can be seen from the slower motion when the battery has to be renewed. In order that the apparatus may not continue in motion when it is not in use each is provided with a special mechanism by which a battery can be inserted or withdrawn. This consists of a vertical axis, *t* (Figs. 7 and 8), which passes through a corner of the middle square plate, and is provided at its upper end with a handle, *u*. Two excentric discs, *y* and *z*, insulated from each other and from the axis by ivory, are placed on this axis; close opposite to them stand the insulated springs *v* and *w*, on the one side and the spring, *x*, on the other. The springs, *v* and *w*, communicate with the poles of a galvanic battery, the insulated discs, *y* and *z*, form the ends of the conducting wire; the one is, therefore, in connection with earth and the other with the bent lever, *o*. If the handle is turned so that the discs, *y* and *z*, come in contact with *v* and *w*, the battery is joined up, and the apparatus must set itself in motion; when turned back, both discs touch the spring, *x*, when freed from the springs *v* and *w*, and are therefore brought into communication with one another. If the handles of both telegraphs inserted in one circuit are in the last position, the circuit is closed; all, therefore, that is required to set the apparatus in motion is the turning of one handle. If, then, the other handle is also turned both batteries are in action, and the velocity of both apparatus is doubled if the batteries are of equal strength.

If the above described apparatus are to be used without an arrangement for printing messages a call can be used with them in the usual way. The remaining parts shown in the drawings constitute the printing arrangement.

A thin turned disc, *a*, of hammered German silver is placed on the axis, *d* (Figs. 7 and 8), near the lower bearing; it is strengthened on the rim with a ring. On the under side of the ring the signs corresponding to the dial are engraved at equal

distances apart. The disc has a radial cut between each pair of types so as to form 30 springs, united at the centre, each of which has a type at the end.

Below the types a revolvable paper roller, *b* (Figs. 7 and 9), is placed so that one of the types is always just over its highest point. The paper roller is covered with black transfer paper, above which a smaller paper strip passes. If, therefore, a blow is given to the type immediately over the roller it must appear printed on the underside of the white strip of paper. The type disc is so arranged that the letter to which the needle points is always at the printing place. The blow is given by one end of a bent lever, *c'*, when the hammer, *d'*, falls on it. The other end of the bent lever carries a light hammer, which strikes simultaneously against a bell. The apparatus can therefore also be used for giving acoustic signals. A spring is placed under the bent lever *c'* which after the blow raises it, together with the hammer resting on it, so far that the depressed type is again set free.

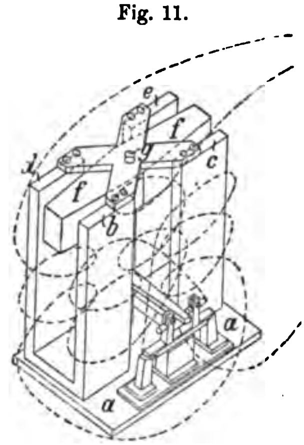
The hammer is raised by the armature, *f*, of the electro-magnet, *g g'*, when a current passes through its convolutions ; it falls down when this current is interrupted. This happens when the instrument is at rest. Attached to the insulated piece, *h'*, is the insulated metal piece, *i'*, and the double-armed lever, *k'*, one end of which is pressed by a weak spring against the metal piece, *i'*. In the other end of the lever a ruby is set against which the lever, *g*, of the telegraph strikes shortly before it is arrested by striking on the stop, *n*. The contact between *k'* and *i'* is therefore always interrupted on the completion of the backward impulse of the telegraph, but immediately made again when it advances. If *i'* and *k'* are now inserted in the circuit of the battery of the printing magnet, *g'*, no current traverses its convolutions when the telegraph is at rest, for then the lever, *g*, rests on the ruby of the lever, *k'*. But as soon as the telegraph is set in motion the armature of the printing magnet must be attracted, and the hammer consequently raised and kept raised whilst the telegraph is in action, for the short interruptions of the current at the end of each oscillation of the lever, *g*, occur too quickly to allow the armature to fall. This motion is fully secured by a proper choice of the strength of the battery of the printing magnet. In order, nevertheless, to obviate, even with the printing mechanism, the disadvantageous

influence of the changing strength of the battery, and especially to assure the fall of the armature under all circumstances, the precaution is taken that the current traversing the convolutions of the electro-magnet ceases altogether or partially when the hammer is raised and the magnetism has therefore finished the work it had to do. This is effected by the attraction of the armature being limited by an insulated stop through which a shunt of very slight resistance is established and the convolutions are thereby cut out. If the resistance of the shunt is exceedingly small in comparison with that of the convolutions, hardly any current passes through the latter; the armature must then commence to fall off. Immediately after, however, the shunt is interrupted and the armature consequently again attracted. The armature must therefore, vibrate after the manner of the magneto-electric hammer, and whatever the strength of the current, must fall off. equally quickly and certainly. Instead of making the resistance of the shunt exceedingly small it can, however, be made so great that the simultaneous current passing through the convolutions suffices to hold the hammer. I employ this method of assuring the fall of the armature without the current of the active battery being interrupted, when the armature is attracted, as with telegraph magnets, in every case where the total interruption of the current cannot be employed, as, for instance, in alarm arrangements and bells. It is also applicable for assuring the action of telegraphs with arbitrary or independent interruption of the current.

The paper roller, *b′* (Fig. 9), rests on a brass tube, *l′*, slit in its length, along which it is movable in the direction of the axis. In this tube, which turns in bearings, *m′* and *n′*, is a cylindrical metal piece, *o′*, which is connected with the paper roller through the slit. The screw, *p′*, lying in the interior of the tube passes through the metal piece, *o′*, and works in its thread. If the screw is turned, the metal piece, *o′*, moves forward, and with it the paper roller, in the direction of the axis. Behind the bearing, *n′*, are placed the two toothed wheels, *g′* and *i′*, of which the first is fixed to the tube, the other to the screw. Their diameters are equal, but one has a tooth more than the other. Both gear into a broad pinion. In this way a slow lateral movement is always combined with the rotation of the paper roller, which prevents the printing from

losing its clearness through the complete wearing out of the transfer paper. The bearings of the paper roller rest on a slide, *s'*, which may be drawn out without difficulty when the paper roller has to be taken out or a new paper strip inserted. Behind the slide stands the bearing, *t'*, with the ratchet, *u'*, the axis of which coincides with that of the slit tube and of the paper roller. If the slide is pushed back the ratchet, *u'*, and the toothed wheel, *r'*, are connected by means of a coupler. The ratchet, *u'*, is pushed forward a tooth each time by the pawl, *v'*, when the armature of the printing magnet is attracted and the pawl thereby

Fig. 11.



depressed. In this way the white paper strip is moved on after each impression by the breadth of a letter ; the writing appears consequently in a continuous line on the strip. Fig. 11 represents an arrangement which has for its object the releasing of signal bells on railways or the insertion of branch telegraphs. On an iron plate, *a*, stand four iron rods or plates, *b*, *c*, *d*, *e*, provided with coils of wire. Their upper ends project beyond the coils. The wires of the convolutions are so joined that the bars, *b* and *c*, have similar, *d* and *e*, opposite polarity. Between these four bars is the steel magnet, *f*, which is carried by the perpendicular axis, *g*. The ends of the steel magnet are always attracted by the two diagonally opposed poles of the electro-magnet and simultaneously repelled by the other two when a current passes through the coils.

If the direction of the current is reversed, the direction of all the attractions and repulsions is reversed; the steel magnet must, therefore, turn, and can always by this motion do mechanical work. As, however, it is indifferent to the magneto-electric apparatus in which direction the current passes, by inserting such apparatus at certain points of the line continuous mechanical actions can be brought about. For instance, bells can be set going without stopping the service of the telegraphs. This arrangement has the advantage over other known combinations of steel and electro-magnets that the magnetism of the first cannot be diminished, for its poles are always attracted by opposite poles.

The electro-magnets used by me differ from those hitherto used essentially in that I employ, instead of massive pieces of iron, bundles of covered iron wires, or iron wires otherwise insulated from one another. It thus becomes possible to give the armature much larger dimensions without reducing in the least the speed of the reversals of magnetic intensity. The retardation of the reversal, with thick iron cores, has for its cause the induced currents produced in the iron mass. With massive iron cores or uninsulated iron wires this retardation is so considerable that one is compelled to use very thin magnets, and consequently very light armatures. Only indirect working or only releasing magnets must be used, therefore, with quick working apparatus if the speed is not to be too much reduced, whilst the use of magnets with insulated iron wires does away with clockwork without necessitating stronger currents or reducing the speed of the apparatus.

What I consider as new and essential, and desire on that account to patent, is:

1. The automatic reversal of the current, effected by means of a movable piece of metal.

2. The method described of assuring the motion of the tread wheel by pushing a solid or spring stop between its vertical teeth.

3. Obviating the possibility of the sticking of the armature of an electro-magnet by the insertion of a shunt at the moment of arrest.

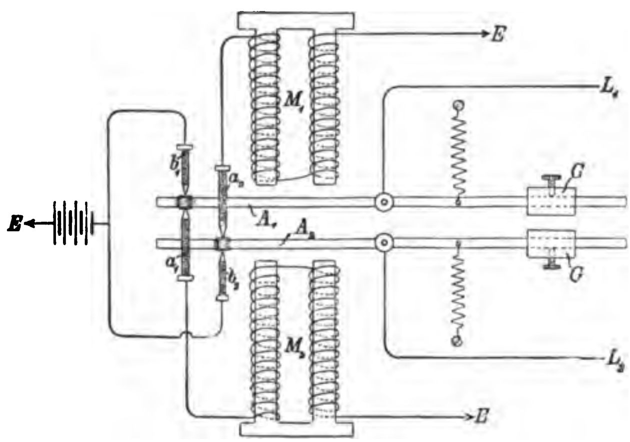
4. The combination of steel and electro-magnets, as described, by which the weakening of the magnetism of the steel is obviated and the motion of the former assured with any strength of current.

5. The construction of electro magnets with insulated iron wires.

THE OLDEST RELAY.*

THE firm of Siemens and Halske sent to the competition announced by the telegraph committee of the Prussian general staff for the 15th March, 1848, a relay for their needle telegraphs, which allowed of the automatic translation of messages from one circuit to a neighbouring one. This relay worked very well; its special construction appears to have been entirely forgotton afterwards—even by its inventor, Werner Siemens—and notwithstanding all endeavours its construction has not yet been authentically discovered. The original pattern is hardly still in existence. A facsimile belonging to the Berlin Post-Office Museum, exhibited in Paris in 1881, and described by Prof. E. Zetsche in his handbook of the electric telegraph in 1877 (Vol. I., p. 529), as well as in the "Electrotechnische Zeitschrift" (pp. 352 and 500), 1881, belongs to a later, probably not exactly similar design; in particular it is questionable whether the apparatus actually comprised as an essential part the fork-shaped slides referred to in the articles mentioned. The researches hitherto made, and, indeed, not yet

Fig. 12.



* 1848.

concluded, lead to the supposition that that relay already realized the double-relay translation as diagrammatically represented in Fig. 12.

The two lines L_1 and L_2, between which there is to be translation, are connected to the armatures A_1 and A_2 of the two electro-magnets M_1 and M_2. So long as no current passes through either of them, these armatures are held by springs on their back stops a_1 and a_2. G G are movable weights for regulating. A current coming from L_1 passes through A_1, and a_1 to the convolutions of the electro-magnet M_2, and then to earth. In consequence of this, the armature A_2 is thrown against the contact b_2, and in this way a current from the local battery is sent through b_2 and A_2 into the line L_2. Inversely every current impulse coming from the line L_2 calls forth one of corresponding duration in L_1.

GERMAN EXPERIMENTS ON THE INSULATING PROPERTIES OF GUTTA PERCHA COVERED ELECTRIC WIRES BY MR. WERNER SIEMENS.*

HAVING read a report in the *Times* newspaper of some experiments which have lately been made by the South Eastern Railway Company at Folkestone Harbour, under the direction of Mr. Walker, with the view of determining the insulating power of a gutta percha coating upon electric conducting wires, I feel called upon to place before the public an account of similar and very conclusive experiments which have lately been tried on a large scale by the Prussian government under the direction of Mr. Werner Siemens, an officer of the Prussian arsenal; and I wish to avail myself of your valuable assistance for that purpose, knowing how deeply you feel interested in the progress of the science of electrical engineering.

During the winter 1846-47, Mr. Werner Siemens commenced his experiments upon the insulating property of gutta percha,

* Mechanics' Magazine, January, 1849.

caoutchouc, and other similar substances, endeavouring to give the line wire of his electric telegraph a coating which would effectually insulate it from the earth in which it should be interred. At that time he obtained a patent in Prussia for his electric telegraph, which is considered quite peculiar, and differing from any other, inasmuch as it constitutes of itself a complete electric machine, the electric fluid being the sole motor, its own regulator, and printer, the advantages whereof are, that it accommodates itself to all irregularities of battery power (provided that power does not fall below a certain minimum); that it profits to a certain extent by bad currents, is very easily managed, and requires but one line wire.

In the summer of 1847, Mr. Siemens obtained permission to try his telegraph upon an established line between Berlin and Potsdam (a distance of about fifteen English miles), where it has since been permanently adopted, in preference to the needle telegraph which had been previously used. In order to remove a general prejudice against the introduction of electric telegraphs, on account of the great expense incurred in suspending, maintaining, and guarding the line above ground, and from fear of frequent interruption from heavy rains, tempests, or mischief, Mr. Siemens renewed with increased vigour his experiments on insulating wires. Gutta percha appeared to him objectionable on account of its tendency to become a hydrate, in which state it is an electric conductor; he therefore tried a wire, four miles long, coated with caoutchouc, which was laid thirty inches below the surface of the earth. The insulation, however, was imperfect; and having improved his method of rendering gutta percha free of water, and also of laying it upon the wire (between grooved rollers), he returned to that substance, and completed a length of thirteen English miles, which was laid thirty inches below the surface of the earth, along the railway between Berlin and Grossbeeren. The coating of this line of wire was imperfect at a few places, which however, by means of a novel process of induction, were soon discovered and soldered up; it has been in constant use ever since (about eighteen months), and still continues to give perfect satisfaction.

In March, 1848, an opportunity presented itself to subject the gutta percha coating to a severe trial. The Provisional Govern-

ment of Schleswig Holstein called upon Mr. Siemens, in conjunction with Professor Himly, to protect the harbour of Kiel against hostile men-of-war.

The pressure of time did not permit of extensive preparations. Large bags were made of gutta percha, each containing between 2000 and 3000lbs. (avoirdupois) of gunpowder. They were hermetically sealed and sunk by means of ballast, at various points into the deep water channel. Each of them was provided with an earth wire and a conducting wire, leading along the bottom of the sea to a central station, where each mine could be fired at pleasure, in order to destroy any hostile vessel which came within its reach. Instruments were so placed as to indicate the exact position of each mine to the guard on duty. These wires were tested from time to time, and it was found that they continued in good condition for several months; but by degrees they changed in appearance, and after having been immersed in the sea for six months, the gutta percha was converted into a complete hydrate, and altogether deprived of its insulating property. Coated wires which have been immersed in fresh water for the same length of time, have also clearly indicated some change, but only in a very slight degree. These results caused Mr. Siemens to try fresh experiments; and he finally succeeded in preparing a gutta percha composition, which, as far as his experiments go to prove, has no affinity for water.

So strong, indeed, is the faith of the Prussian Government's Electric Committee in the success of this coating, that they have adopted it for all their lines in course of construction. Mr. Siemens has just completed a telegraphic communication between Berlin and Frankfort-on-Maine (a distance of 445 English miles), and another line from Berlin to Cologne is completed as far as Magdeburg. In Hanover, and other states of Germany, the same description of telegraph has also been adopted.

This great length of copper wire is coated by means of one single machine which has been constructed by Mr. Siemens and a Mr. Halske conjunctively. It consists of a horizontal cylinder, with a movable piston; a chamber at the end of this cylinder is pierced with sixteen holes, eight of which are through the bottom, and of the same diameter as the wire itself; the remaining eight are through the top side, exactly opposite to those in the bottom,

and are of the intended diameter of the coated wire. Eight separate wires are pointed through the bottom holes ; the cylinder is moderately heated, and filled with gutta percha composition, whereupon the piston is urged forward, and, in forcing the semi-fluid substance through the eight larger holes, it carries with it the coated wires with remarkable velocity, the wire itself being impelled by virtue of adhesion to the gutta percha which surrounds it.

In going through large rivers, such as the Elbe, the Weser and others, Mr. Siemens has encased the coated wire in iron pipes, in order to protect it from damage.

ENGLISH PATENT REGARDING ELECTRO-MAGNETS, POINTER AND PRINTING TELEGRAPHS, TRANSLATORS, ALARMS, KEY APPARATUS, AND ARRANGEMENTS FOR THE PRODUCTION AND LAYING OF UNDERGROUND LINES.*

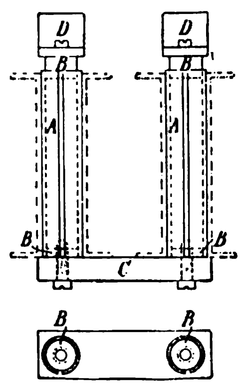
I. Electro-magnets.

In constructing electro-magnets for telegraphic purposes it has been found that when the iron employed is of large dimensions, the magnet requires a certain time to attain its full power, and also retains its magnetism for some time after the contact is broken. To avoid this defect it is usual to employ small masses of iron, and the power of the magnet is thus reduced, although its rapidity of action is increased. I have succeeded in overcoming these defects by employing hollow iron tubes cut open in a longitudinal direction in place of the solid iron commonly employed. I have found that I can thus employ comparatively large magnets, and obtain great power combined with great rapidity of action. This appears to be owing to the longitudinal separation effectually preventing the formation of circular currents within the iron itself.

* English Patent, 13062, of 3rd April, 1850.

Figure 13 represents a side view and horizontal section of a horse-shoe magnet constructed in this manner. AA are the two branches or legs, each formed of a divided iron tube ; these legs are encased with bobbins, on which the coils of wire are wound in the usual manner. BB are solid pieces of iron welded or otherwise fixed in the iron tubes AA. C is a solid piece of iron connecting the two legs. The poles of the magnet are enlarged by attaching to them the pieces of iron DD. The iron tubes may be divided in two or more places, or a bundle of iron wires insulated from one another may be employed ; in either case the ends are connected to solid pieces of iron to form the poles. I sometimes employ a straight divided tube of soft iron in place of a horse-shoe magnet, and make use of the attractive power of one pole only. The other pole is then placed in contact with a large piece of soft iron, which serves as a reservoir of the opposite and unemployed magnetism. By this means I obtain from a straight magnet, the same attractive force, or nearly so, as from a horse-shoe magnet with the same quantity of wire. I provide the poles of my magnets with iron plates of such dimensions that their weight is equal to about one-third of that portion of the magnet which is immediately surrounded by the coils, and I make the attracting surfaces of these plates about twice, and sometimes even three times, the area of the iron rod or tube which forms the magnet. These plates serve as reservoirs for the magnetism produced by the current, and thereby increase the effective power of the magnet. In some cases I employ, in place of an electro-magnet, and a soft-iron armature, two electro-magnets, of which one is fixed and the other movable. The movable magnet consists of a straight piece of iron, which is bent rectangularly at both ends. Round the longer central part is placed the coil of wire which, however, is not wound upon the magnet, but upon a bobbin within which the magnet turns freely upon its axis while the bobbin remains stationary. The two bent portions form the poles of the magnet,

Fig. 13.



and are placed in proximity to another electro-magnet, or to a soft iron armature. When a current of electricity is passed through the coils, the movable magnet turns on its axis to a certain extent, which is limited by fixed stops. When two electro-magnets are arranged in this manner, I obtain the advantage of the combined power without the disadvantage of the great inertia which attends movable electro-magnets of the ordinary forms. In using these double magnets, I either break and restore the currents of both magnets simultaneously or cause a constant current to pass through

Fig. 14.

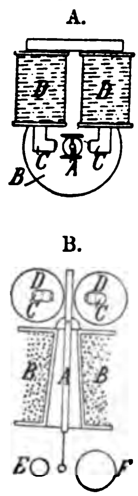
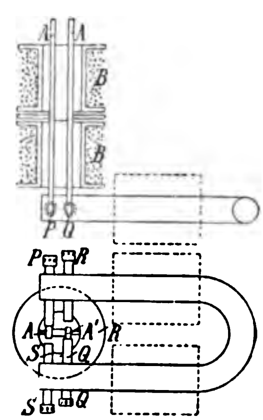


Fig. 15.



the coils of one magnet, and alternately break and restore the current in the other, or I reverse alternately the direction of the current in the last-named magnet. The part of the magnet within the coil is made hollow and cut open in a direction parallel with the axis, as above described. Instead of the magnet being bent at the ends, and suspended so as to turn upon its own axis, it may be straight and suspended on a transverse axis as shewn in Figure 14. A is the straight electro-magnet, which will have a tendency to place itself in the axis of the coil B, when that coil is traversed by an electric current; C is a horse-shoe electro-magnet, covered with coils D, and having its two poles in proximity to the electro-

magnet A. If a current be passed through the coils D, the magnet C will cause the magnet A to deflect in one or other direction, according to the direction of the current. Figure 15 represents another form of this description of magnet, in which two pieces of iron, A and A′, are included in the coil B, and mounted upon separate axes, or loose upon the same axis, so as to move independently of one another. In their position of rest they are kept in contact with the stops P and Q by means of springs, or by gravity or otherwise. When currents of electricity are passed through the coils, one or other of the electro-magnets A A′ is deflected against the stop R or S; on reversing the current it falls back to its original position, and the other electro-magnet A′ or A is deflected.

Fig. 16.

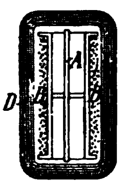
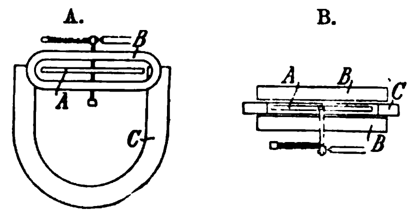


Fig. 17.



This arrangement has the advantage of preventing vibration, and rendering the movements more decided.

Figure 16 represents an instrument in which A is the electro-magnet, or two separate electro-magnets, as in Figure 15, turning on a transverse axis in the coil B, which is continually traversed by an electric current, thereby not only rendering A magnetic, but giving it a tendency to place itself centrically in the axis of the coil B. This coil is surrounded by a coil D, like the ordinary galvanometer coil, which deflects the electro-magnet or the electro-magnets A in one direction, or in the other according to the direction of the current passing through the coil D. The motions thus produced may be applied to giving signals by moving an index or dial, or for moving detents and ringing alarms, or for making contacts for local batteries, and generally for telegraphic purposes.

Figure 17 represents an instrument in which an iron needle A is surrounded by coils of wire B in the manner of a galvanometer;

C is a steel magnet, or an electro-magnet, the proximity of which renders A magnetic by induction, and this causes it to deflect like the needle of an ordinary galvanometer when an electric current is passed through the coils D. This instrument is not new, and I lay no claim to the employment of it except when in combination with another similar or different instrument so arranged that the action of the first makes or breaks the contact of the second, and the action of the second reciprocally makes or breaks the contact of the first, as hereinafter described.

Although I have spoken of using iron in the construction of the magnets, it is evident that other metals capable of receiving magnetism, such as nickel, may be employed, but I consider iron to be the most advantageous.

II. Electro-dynamic Arrangements.

In place of employing electro-magnets I sometimes employ spirals of iron wire or strip, the coils of which are separated by

Fig. 18.

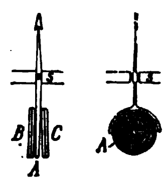
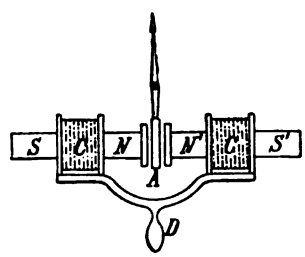


Fig. 19.



intervening layers of non-conducting material, and I pass the electric current through the spiral wire or strip. Figure 18 shows an arrangement of this sort. A is a spiral of iron wire covered with silk and traversed by an electric current. This spiral is suspended on an axis S parallel to the plane of the spiral. B C are two fixed spirals arranged so as to be traversed in opposite directions by the electric current. The movable spiral will be attracted to one side or the other according to the direction of the current which passes through it. The motion thus obtained may be applied for tele-

graphic purposes generally. The last described arrangements of spiral wires may also be constructed of copper or other non-magnetic metal, but will not be so powerful as if made of iron. When made of non-magnetic metal they have, however, the advantage of acquiring and losing their power instantaneously when the current is established or broken. These spirals may be appropriately designated as electro-dynamic arrangements. These electro-dynamic arrangements may be varied in form, provided the electro-dynamic principle be retained of causing one wire conducting an electric current to produce motion in another wire also conducting an electric current. Thus, if a movable wire be suspended above a fixed wire and at right angles to it, and an electric current be then passed through both wires, the movable one will endeavour to place itself parallel to the fixed wire, and in doing so will turn to the right or to the left, according to the direction of the current.

Figure 19 represents an electro-dynamic spiral A suspended between the similar poles of two steel magnets N S, N′ S′. A current being passed through the spiral A will cause it to move towards one magnet, and on reversing the current it will move towards the other magnet. When the current ceases the spiral will be brought to the central position of rest by the action of gravity, or by a spring or otherwise. In this figure is shown the method of producing the electric current by induction from the same magnets which are employed to act upon the electro-dynamical spiral. C C are two bobbins covered with coils of wire and connected together by the handle D. The coils of wire and the spiral A are all included in the current of the line wire. By suddenly moving the handle D to the right or to the left an electric current is produced in the coils, and passing through the spiral A and along the line wire, and through a similar apparatus at the distant terminus and at each intermediate station, it produces similar motion in the spirals at all the stations. Electricity thus obtained by the motion of a coil over a magnet may be applied for deflecting needles or magnets, for working electro-magnets, step-by-step motions, and printing apparatus, for releasing detents and ringing alarms, and for telegraphic purposes generally. The form and arrangement of the apparatus may be varied by employing curved or horse-shoe magnets, or by fixing the coils and making the magnet movable within them, and in various other ways.

III. Conducting Contact Pieces.

In different descriptions of telegraphic apparatus great inconvenience has been experienced in consequence of the destruction of the metallic points of contact when the galvanic current is alternately broken and restored, which circumstance has rendered the use of transmitting instruments in particular very precarious. The metal often used in making these points or surfaces of contact is platinum, which, through the agency of the electric spark, is gradually removed from one point or surface and settles on the opposite surface in the form of a spongy substance with imperfect conducting power of electricity. Gold and silver give a still more unfavourable result, and more oxidizable metals are burnt away. I remove this difficulty by using hard alloys of the non-oxidizable or precious metals, in particular of platinum, or iridium or palladium, with gold or silver and of other combinations between those metals; an excellent alloy is made of one part of gold with one part of platinum or palladium or iridium. Surfaces of contact which are made of these metallic alloys preserve their original form and metallic nature for a great length of time.

IV. Automatic Indicating Instrument and Alarm.

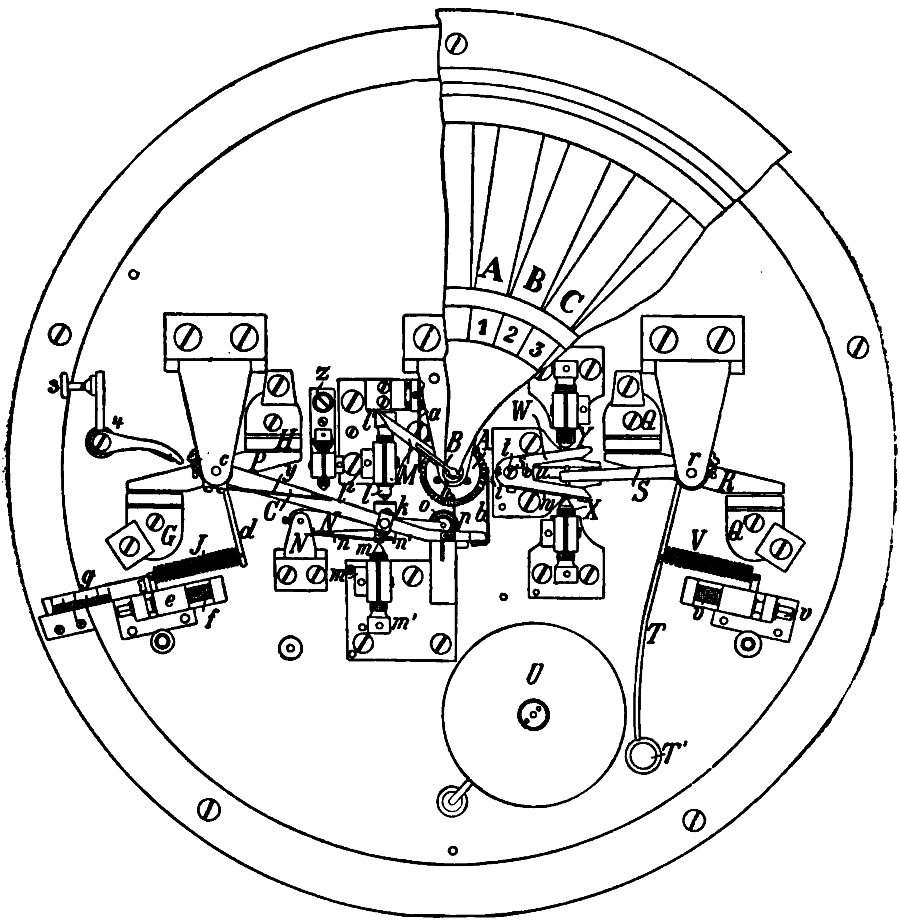
Figures 20A, 20B represent an instrument which conveys signals by means of an index pointing to letters or symbols, and worked by a step-by-step motion. A is a ratchet wheel, which carries the index B and also an arm M: *a* is a pawl or click which prevents the ratchet wheel from turning backwards; *b* is another click, attached to the lever C, which is fixed to the iron armature P of the electro-magnet F; G and H are the two poles of a magnet, which in attracting the armature P, cause it to turn on its axis *c* and thus to give motion to the lever C; an arm *d* is fixed to the armature, and a spring J is connected at one end to this arm, and at the other end to a sliding stop *e*, which is capable of being adjusted by means of the screw *f* and graduated scale *g*. Each time that an electric current is passed round the electro-magnet the armature will be attracted, and the click *b* will move forward over one tooth of the ratchet wheel. When the circuit is broken and the current

ceases, the spring J will draw back the lever C and click *b*, thus causing the index to move one division. The ratchet wheel A carries a second set of vertical pins or teeth into which the catch *h* locks. This catch is fixed to the lever C, and serves to prevent the ratchet wheel from overrunning. When the lever C moves forward, the catch *h* unlocks the wheel, and as the lever returns it locks the next tooth. There is, however, a possibility of the wheel being flung round by the elasticity of the lever, before the catch *h* has time to enter. This is prevented by the small screw or stud *i*, which confines the tooth and prevents the wheel from overrunning. N is a lever, on which is fixed a cross plate *k*, turned up at each end, which may be called the fork. This lever is moved backwards and forwards by being struck by two studs of agate or other non-conducting substance on the lever C, and its motion is confined and limited by the non-conducting stud *l* and the metallic point *m*, both of which are capable of being adjusted and fixed by the screws l', m', and the set screws l^2, m^2. A slight spring *n* is attached to the lever N, and is confined to a very small amount of motion by a small projection or hook n', attached to the piece *k*; this prevents the contact being broken by any slight rebound of the lever. The end of the lever N is thin and elastic, and carries an obtuse-pointed steel pin, *o*, which rests upon a prism or angular piece of agate, *p*. By this arrangement the lever N is retained in its position, whether it is in contact with the stud *l* or the point *m*. If one pole of a galvanic battery be now connected to the bearing N′, which supports the lever N, and the wire from the other pole be connected to the coils of the electro-magnet and then attached to the support of the point *m*, the consequence will be that the armature P will be attracted, and the lever C will move forward until it strikes the piece *k*, and thus moves the lever N forward, and by that means breaks the contact at the point *m*. The contact being thus broken, the electro-magnet loses its magnetism, and the lever C is drawn back by the spring J, and the ratchet wheel advances one tooth. The contact is now restored by the lever C striking the fork *k* and shifting the lever N, when the armature is again attracted and the various motions are repeated.

The ratchet wheel is thus caused to revolve with rapidity, the index pointing to all the letters in succession as long as the con-

nection with the battery is maintained. If the wire from the point *m*, instead of being connected at once to the battery, is carried along as a line wire through a similar instrument at a dis-

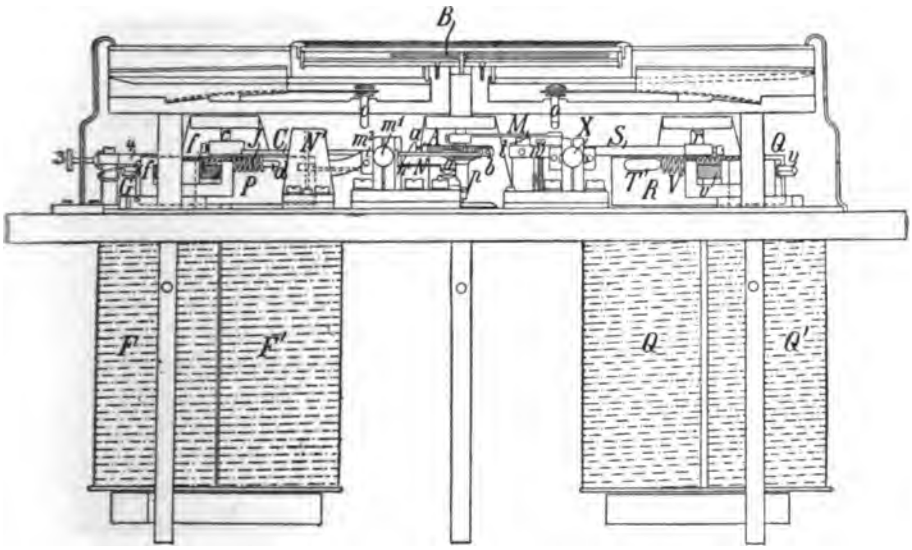
Fig. 20A.



tant station and thence into the earth, and a wire is connected from the earth to the pole of the battery, the consequence will be that both instruments will work in unison, and the index at the distant station will point to the same letter simultaneously with

the first instrument. A set of keys are arranged round a dial, a portion of which is shown in Fig. 20A. Below each key a pin, O, is placed which can be pressed down by the key and thus obstruct the arm M. The pins O are so placed that the motion of the arm M is arrested just as the lever C is on the point of commencing its backward movement. By this means the remaking of the contact *m* is prevented, and therefore the index and ratchet wheel stop, and the signal is given by the stopping of the index opposite the

Fig. 20B.

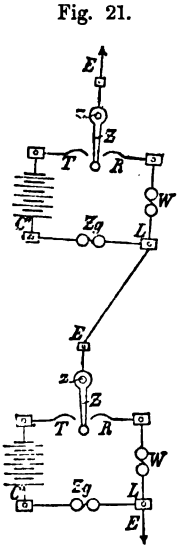


lever or symbol. On releasing the key, the pin rises and the lever C falls back and restores the contact, and the motion of the ratchet wheel is resumed. If, owing to loss of electricity in the line wire, or any other cause, one of the instruments be traversed by a current of greater power than the other, still this does not prevent the proper action of the instruments, as it is evident that neither of the electro-magnets can be brought into action until the contact has been restored in both instruments, so that the quicker acting instrument has always to wait for the slower one before another stroke can commence. If one instrument is acted on by a very much more powerful current than the other the springs

should be adjusted so as to reduce the resistance to the motion of the instrument worked by the weaker current. It is evident that similar instruments may be placed at the intermediate stations and traversed by the same currents.*

Alarm or bell-apparatus.—In Fig. 20B, Q, Q′, are the two poles of an electro-magnet; and R is the armature, turning on the centres *r*, and carrying the lever S, and the long arm T at the end of which is the hammer T′, for striking the bell U. The arm T is pulled back by the spring V, which is adjusted by the screw *v*. The lever S carries two small studs of ivory, or other non-conducting material, which, striking against the sides of the fork W, rotates it on its axis, bringing it alternately into contact with the metallic point X, or with the non-conducting stud Y. The electric current is completed through the point X and the fork W, and a small spring, *w*, similar to that marked *n*. The fork W turns on the pin *t*, and is provided with a small screw, *s*, which presses upon a little spring, *v*. The spring produces sufficient friction to retain the fork W in the position into which it is thrown when struck by the lever S, but not sufficient to prevent its motion when so struck. When a current of electricity passes round the electro-magnet Q, Q′, the armature R is attracted, and the hammer strikes a blow upon the bell U. At the same time the fork W is

Fig. 21.



* When several dial instruments are inserted in one line, the interruption of the current in the apparatus, which first completes the attraction of its armature, effects at the same time the stoppage of the current in the whole line, so that in the rest of the instruments no real self-interruption takes place.

The following device, patented in Prussia on February 7, 1852, was therefore adopted, which has been added to Fig. 20 to save repetition.

The oscillating lever *c* was fitted near its pivot with a spring *y*, by touching which the contact screw on the piece of metal *z*, after the completion of or already during the oscillation, connected the line wire direct to earth (or, in intermediate instruments, to the outgoing line). This contact lasted during half the period of the back movement of the armature, and thus gave the other instruments connected to the line sufficient time to complete the attraction of their armatures, and to interrupt the current themselves. By this device simultaneous action of all the apparatus was assured, even if some of them were less accurately adjusted than the rest.

thrown against the stud Y and the contact is broken at the point X. The armature is thus drawn back by the spring V and the fork W is thrown against the point X.

Circuit (Fig. 21).—Z is a lever turning upon the centre *z*, and capable of being moved by hand, so as to place it in contact either with the metallic spring T or the opposite one, R. The lever Z is in connection with the binding screw E, which is placed in communication with the earth. The spring R is connected to a wire which connects it with the coils of the alarum magnet, W, whence a connection is made to the line wire by the binding screw L. The spring T is placed in connection with the zinc pole of a galvanic battery, and the copper pole of the same battery is connected to the screw C^1, from which a connection is made to the coils of the electro-magnet Z *g*, and thence to the line wire through the binding screw, L. The line wire passes along to the first intermediate station, where it is connected to the screw E of the instrument at that station. A wire from the screw L of that station then passes along to the next intermediate station, and so on until it arrives at the distant terminus, where it is connected to the screw E of the instrument at that terminus, while the screw L at that terminus is connected to the earth. At each station a battery is connected to the screws Z′ and C′, so that its zinc pole may be in connection with the screw Z′ and its copper pole with the screw C′. The levers Z of all the instruments being moved towards the spring R, all the instruments will be in repose, and all the alarums will be included in the circuit, while the indicating instruments and batteries are excluded. If now the lever Z of one of the instruments is moved over towards T, the effect will be to introduce into the circuit the battery and the indicating instrument at that station, which may be called the active station, while the alarum at that station is excluded, the other alarums remaining in the circuit. The current now passes along the line, and produces magnetism in the electro-magnet of the indicating instrument at the active station and in the alarum magnets at all the other or passive stations. The consequence is that the hammer strikes the bells in all the passive stations, and the indicating instrument at the active station would also be set in motion were it not prevented by the following contrivance. The springs of the alarum armatures are adjusted to be much weaker than those of the indi-

cating instrument, and the consequence is that the alarum armature is attracted, makes a stroke, and breaks the contact before the armature of the indicating instrument has overcome the resistance of the spring. The alarums are thus rung without the index of the indicating instrument being set in motion.

The attention of the attendants at the passive stations being thus called, they move their levers Z towards the letter T. As soon as the last lever Z has been placed in that position and the last alarum thus excluded, the current will acquire sufficient duration to cause the attraction of the armatures of the indicating instruments, which will then all start off together, and the signals may then be given by depressing the keys, as already described.

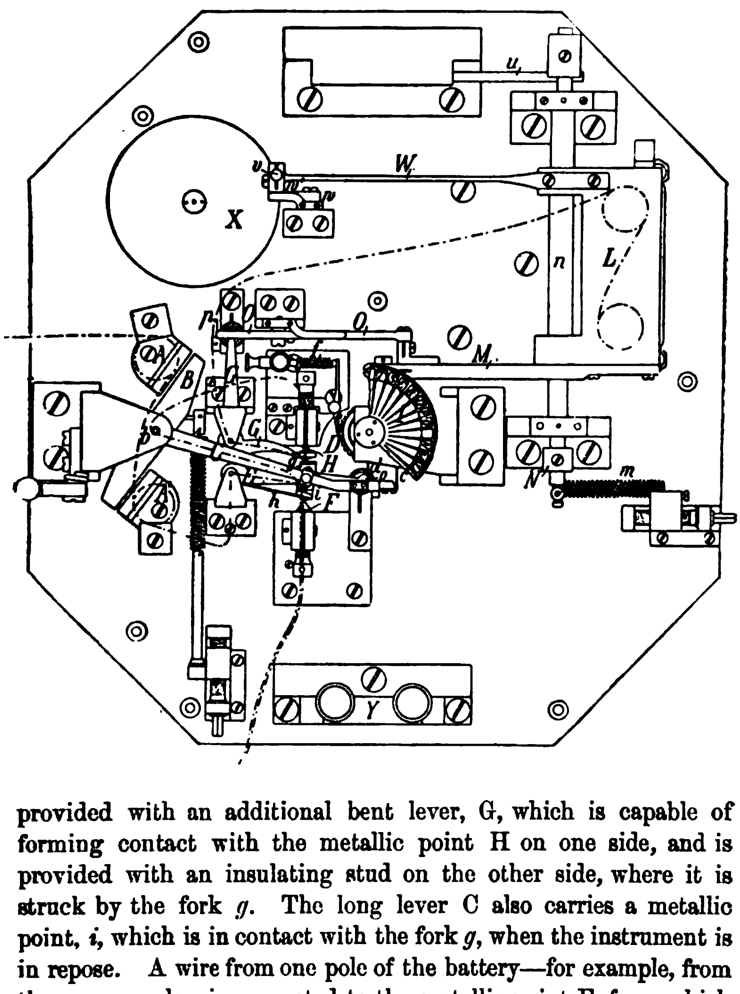
If it be wished to exclude any station from the circuit for a time, it is done by connecting the screws E and L, either by a wire or by a finger-key or button, as is well understood. In this case care should be taken that the index is brought to its proper position of repose before the instrument is reintroduced into the circuit, otherwise on recommencing a new signal its indications would not correspond with those of the other instruments. 3 is a small button acting on the bent lever 4, by means of which the instrument can be worked by hand, so as to bring the index into any required position.

V. Printing Telegraph.

Fig. 22 represents a plan, and Fig. 23 a section, of a printing telegraph, working by a step-by-step motion. A A^1 are the poles of an electro-magnet A^2; B is the armature, turning on the centre *b*, and carrying the long lever C, which carries a click *c* and locking piece *d*, similar to those in the indicating instrument already described. D is the ratchet wheel; and *e* is a click, kept up by the spring F. The ratchet wheel D carries a type wheel I, which consists of a number of thin springs, each carrying a type at its extremity, except one or more which are left blank. These types and blanks correspond with the letters or signs and blanks on the dial of the indicating instrument already described; and it will be readily understood that if both instruments are included in the same circuit they will move together, and the dial of the printing instrument will simultaneously present similar letters or signals to

those pointed to by the needle of the indicating instrument. For this purpose the printing instrument is provided with a lever E, and a fork g, spring h, and contact point F. The motion of the lever C breaks and makes contact with the point F, as in the indicating instrument. The printing instrument, however, is

Fig. 22.



provided with an additional bent lever, G, which is capable of forming contact with the metallic point H on one side, and is provided with an insulating stud on the other side, where it is struck by the fork g. The long lever C also carries a metallic point, i, which is in contact with the fork g, when the instrument is in repose. A wire from one pole of the battery—for example, from the copper pole—is connected to the metallic point F, from which

the electricity passes into the lever E, and thence round the coils of the electro-magnet A^2, and then passes through the indicating

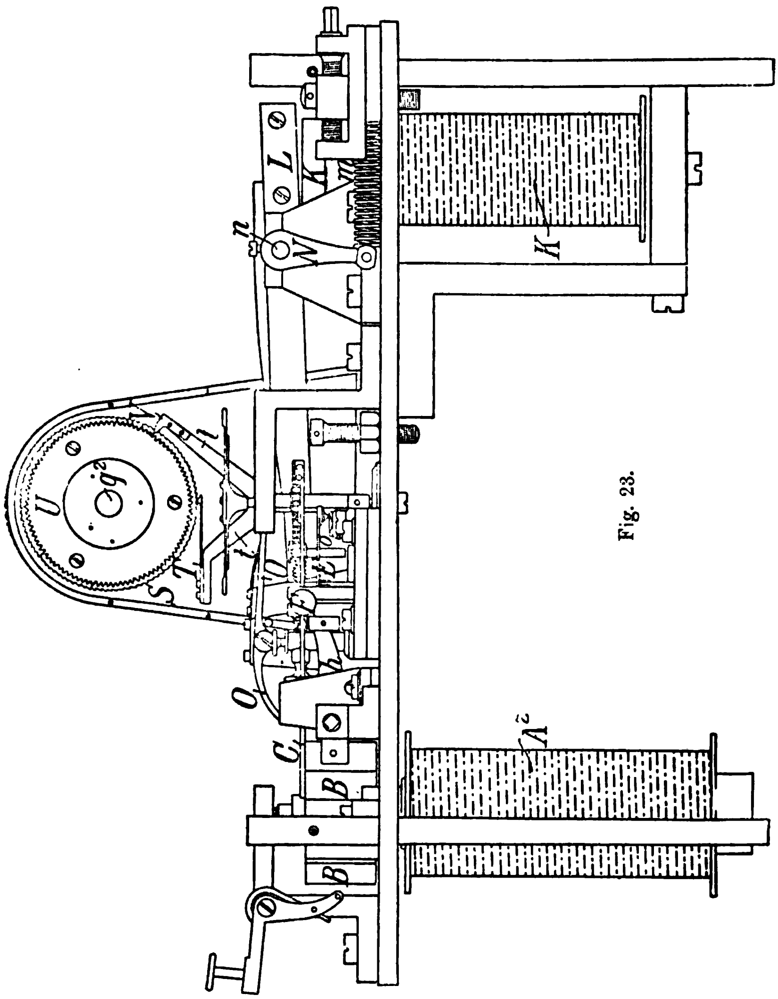


Fig. 23.

instrument above described, and along the line to the instrument at the distant station. Another wire passes from the zinc pole of the battery into the earth. This is all that is required to

move the type wheel I; but as it is necessary to strike the type to produce an impression on the paper, the following parts are added for that purpose: K is an electro-magnet, and L is its armature. This magnet is made of solid iron, and its armature is much heavier than that which works the type wheel. M is a lever or hammer fixed to the armature, and adjusted so that it may strike the back of the type spring when the armature is attracted by the magnet; *m* is a spring attached to a lever N on the axis *n* of the armature, for the purpose of drawing it away from the magnet. A conducting connection is made between the axis of the lever C and the metallic point H, and also from the bell-crank lever G round the coils of the hammer magnet, and thence to the zinc end of the battery; but it will be found advantageous not to connect this wire to the extreme end of the battery, but to some intermediate point, so that only a portion of the battery may be included in this circuit. The lever E is provided with a steel point and agate prism, for the purpose of maintaining its position. The bell-crank lever G is also provided with a similar steel point and agate prism.

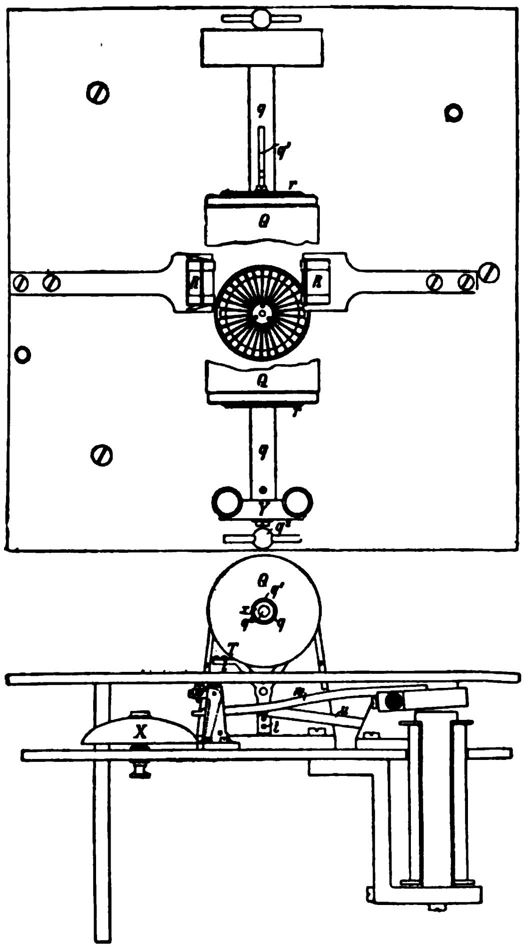
The action of the apparatus is as follows:—The indicating and printing instruments being both included in the circuit, the current passes from the copper pole of the battery through the point F and fork g to the coils of the magnet A^2, and thence through the coils of the magnet which works the lever of the indicating instrument along the line wire, and through similar instruments and a battery at the distant terminus, and then into the earth, returning to the wire which leads from the earth to the zinc pole of the first battery. The consequence will be that all the armatures which work the ratchets will be attracted, and will move their respective levers and clicks forward so as to take hold of the next tooth in their respective ratchet wheels; at the same time the ratchet levers will strike the forks and break the contact, when they will be drawn back by their respective springs, and neither can advance again until all have returned; when the forks will be again thrown into contact with the metallic points, and the circuit being thus completed, all the armatures will be again attracted and make a fresh stroke, and the needles and type wheels will thus all march in unison, and with great rapidity. If now one of the keys in either of the indicating instruments be

depressed, the needle will stop on arriving at the corresponding letter, and the circuit being thus broken, all the other armatures will fall back and remain stationary. The current will now pass round the coils of the hammer magnet and will cause its armature to be attracted, and a blow struck on the type which is then opposite the hammer. As the hammer strikes the blow it also strikes the bent lever O, which moves the lever G, and thus breaks the contact at H; the hammer magnet immediately loses its magnetism, and the hammer falls back. If the key which has been depressed is now liberated the ratchet lever of that instrument will fall back, and the contact being thus renewed all the instruments will start off again and continue their simultaneous movements until again stopped in a similar manner. The first stroke of the ratchet lever C restores the contact between the bent lever G and point H. It will be seen that every time the ratchet lever C falls back it remakes the circuit of the hammer magnet, but as the ratchet lever immediately starts off again and breaks this contact at *i*, there is not time for the comparatively heavy and sluggish hammer magnet and armature to come into action. When, however, the current round the magnet becomes continuous by the breaking of the line circuit in the indicating instrument the hammer magnet has time to acquire sufficient power to attract its armature and to strike the blow.

The printing is effected by means of the cylinder Q (Figs. 24 and 25), made of a number of discs of paper placed on a spindle, *q*, and strongly compressed by a powerful press, and confined by a metallic disc or flange, *r*, at each end. The cylinder thus formed is turned in a lathe, and is covered with an ink formed of oil and lamp black. A strip of paper is passed under the ink cylinder, and guided by two small rollers, R R. The ink is of a sufficiently dry nature not to black the paper by the mere contact, but when the paper is forcibly driven against the cylinder by the blow of the hammer under the type the letter is printed on the side of the paper in contact with the ink cylinder. A ratchet wheel S (Fig. 23) is placed on the spindle *q*, and is worked by a click T on the lever *t*, which is moved by means of a connecting rod, *u*, jointed to a lever on the axis *n* of the hammer armature. U is a toothed wheel, which is locked by the pallet V on the lever *t*. It will thus be seen that the ink cylinder is advanced one tooth each time that the hammer returns after striking a blow. The paper is

thus advanced the width of one letter, so as to present a fresh portion of paper and of ink cylinder for the next impression.

Figs. 24, 25.



Two blank spaces are left in the indicating dial, and two corresponding blanks on the type wheel. When the blow of the hammer is struck on one of these blanks it finds no resistance from the type, and therefore rises rather higher than when striking

a type. The consequence is that the lever W, which is fixed to the armature, strikes against the screw v in the arm of the bent lever w (Fig. 25), and by raising its horizontal arm w' throws its vertical arm against the bell X. The operator in spelling the words of the signal brings up the blank after each word, and the stroke of the bell at once tells him that the instruments are working correctly. If by any accident the indicating and printing instruments should not correspond in their indications, the error is immediately detected by the bell remaining silent when the blank keys are depressed.

The ink cylinder Q (Figs. 24 and 25) is capable of sliding endways on its shaft q, which is made hollow, and has a slot q^1 cut in it. Inside this shaft is a long fine-threaded screw, q^2, which is fixed to the support Y. On this screw is a nut x, which is connected to the ink cylinder by a feather passing through the slot q'. By this means the ink cylinder Q gradually travels along the shaft q, so that every part of it is brought into use. When after continued use the impression becomes faint, the roller may be again charged with ink by dabbing it with a leather ball covered with ink.

This arrangement of printing apparatus preserves the types clean, as they never come in contact with the ink. Similar writing apparatus may be placed at the intermediate stations.

Instead of including in the same circuit the indicating and writing apparatus at both stations, it is advantageous where there are two lines to connect the indicating apparatus at each end with the printing apparatus at the opposite end, as by this means two distinct signals may be passing in opposite directions at the same time. When there is only one line wire, signals may be sent from an intermediate station in one direction while signals are received at the same station from the opposite direction.

In some cases it may be advantageous to employ a printing apparatus by itself, so as to avoid the expense of two apparatus. In this case I construct the printing apparatus with a set of keys, which serve to stop an arm attached to the spindle of the ratchet wheel, in the same manner as above described with regard to the indicating apparatus. The stoppage of this arm will have the effect of breaking the circuit, and causing the letter to be printed at the distant terminus, and at all the intermediate stations which may be included in the circuit. The instrument may be rendered

more convenient for use by arranging the keys in a semicircle instead of a circle. The ratchet spindle is then provided with two arms placed opposite to each other; one of these arms is shorter than the other, and is placed a little lower or higher on the spindle, and half the keys are made to act on the one arm and half on the other. The keys may be conveniently made like the black and white keys of a pianoforte, every alternate key being shorter and higher than the others. The long white keys may then serve for the first half of the alphabet, and the short black keys for the last half of the alphabet. The dials, type wheels, and keys of the printing and indicating instruments, above described, may represent numbers or symbols instead of letters, or a conventional code of signals may be employed, as is well understood.

VI. Translating Apparatus.

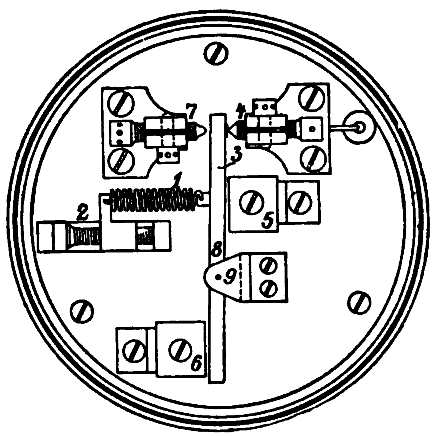
When the line wire is very long, or otherwise presents great resistance, I find it advantageous to work the above described apparatus by a local or auxiliary battery, and to employ the current which traverses the line wire to work a translating apparatus, which makes and breaks the contact of the local battery. The motion of the lever of the step-by-step motion breaks and makes the contact of the translating apparatus. By this reciprocal making and breaking of contact the apparatus is enabled to work with great rapidity, although the current in the line wire may be very weak. I apply this arrangement to the printing apparatus above described, and also to the indicating apparatus above described, and to both these apparatus in combination; I also apply it to the alarum, whether such alarum be altogether separate or combined with the indicating or printing apparatus, or with both those apparatus.

The translating apparatus may be made in a great variety of ways. Fig. 26 shows one form of it. 5 and 6 are the poles of an electro-magnet, the legs of which are below the top of the box; 8 is the armature turning upon the centre 9, and kept in contact with the stop 10 by the spring 11, which is adjusted by the screw 12. The armature carries a small contact piece of metal, 13, which is brought against the metallic point 14 when the armature is attracted by the electro-magnet. The armature 8 and

point 14 form part of the circuit of the local battery, so that the passage of an electric current along the line wire and around the coils of the electro-magnet 5 and 6 effects the completion of the circuit of the local battery by making contact at 14.

I now proceed to describe the course of the currents of the principal and local batteries, which are, of course, different from that of the current when the translating instrument is employed. 15 and 16, Fig. 27, are two additional springs, and a short additional lever, 17, shown by dotted lines, if placed under the lever Z, which gives motion to it by means of an ivory or other non-conducting

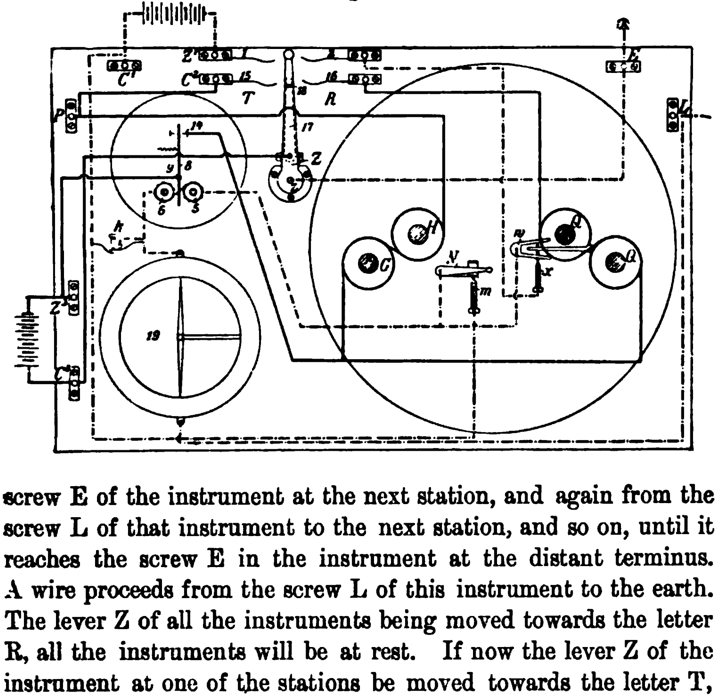
Fig. 26.



pin, 18, so that the two levers move together, but are not in metallic contact. The lever Z is connected to the earth through the screw E; the spring 2 is connected by a wire with the metallic point X, and another wire connects the support of the fork W with the coils of the magnet 5 and 6 of the translating instrument, from which it passes to the screw L, and along the line. 19 is a galvanometer, which may be advantageously introduced in the circuit to show the strength of the current. The spring 1 is connected to the zinc pole of the battery, and the copper pole is connected to the screw C^1, from which the current passes to the point *m*, through the lever N and the support N^1, and thence into the wire which leads to the coils of the transmitting instrument.

The zinc pole of the local battery is connected to the screw Z^3, and the copper pole is connected to the screw C^3, from which a wire proceeds to the short lever 17. A wire proceeds from the spring 16 to the coils of the alarum magnet Q, and thence to the metallic point 14. The piece 9, which supports the spindle of the armature 8, is connected to the screw Z^3, thus completing the circuit of the local battery. The spring 15 is connected by a wire to the screw P, from which a wire proceeds to the coils of the magnet, which works the ratchet wheel, and then joins the wire leading to the point 14. The line wire from L passes to the

Fig. 27.



screw E of the instrument at the next station, and again from the screw L of that instrument to the next station, and so on, until it reaches the screw E in the instrument at the distant terminus. A wire proceeds from the screw L of this instrument to the earth. The lever Z of all the instruments being moved towards the letter R, all the instruments will be at rest. If now the lever Z of the instrument at one of the stations be moved towards the letter T, the battery will be introduced into the circuit of the line wire, and the armatures of all the translating instruments will be attracted, and thus contact will be made at the points 14. The local battery at each station will thus be brought into action, and a current of electricity will pass through the coils of the magnet G

and H at the active station, and through the coils of the alarum magnets Q Q at all the other stations. The armatures of the alarum magnets will be immediately attracted and the bells will be struck, and the forks W being driven forward will break the contact at x, thus destroying the continuity of the line wire. The armatures of the translating instruments will then immediately fall back, and break the continuity of the circuit of the local battery at 14, then the armatures of the alarum magnets will fall back and restore the continuity of the line wire, then the armature of the translating instrument will be again attracted, and so on. The alarum will thus continue to ring. The spring of the armature of the indicating instrument being much stronger than that of the alarum, will prevent the indicating instrument from moving while the alarums are in the circuit.

The attention of the various attendants having been called by the alarums, they move the levers Z of their respective instruments towards the letter T. When all the levers are in this position the currents of the local batteries will be directed round the magnets G and H of the indicating instruments, which will then attract their respective armatures and advance the levers C. As these levers approach the end of their stroke they shift the forks N, and thus break the continuity of the line wire. The armatures of the translating instruments now fall back, and in so doing break the continuity of the circuit of the local battery; the armatures of the magnets of the indicating instruments then fall back and the ratchet wheels are advanced one tooth. The contact is then restored at m, and the current again traverses the line wire and translating instruments and the instruments commence another stroke. All these motions succeed each other with great rapidity, and the instrument is worked by depressing the keys in the same way as when the translating instrument is not employed.

When a printing instrument like that above described is required to work with the indicating instrument it is only necessary to connect the wire from the screw P to the coils of the type wheel magnet and thence to the spring 15; the type wheel will then march in unison with the index of the indicating instrument; the circuit of the hammer magnet will include another local battery, or will be connected with the same local battery, so as to include only a part of it. In place of employing two local batteries and

one principal battery, it is generally more convenient to employ one battery of several pairs and to connect the whole of it to the principal circuits, and only a portion of it to the local circuits. By this means the whole power of the battery will be transmitted through the circuit of the line wire to act upon the transmitting instruments, and as soon as their armatures are attracted a portion of the power of the battery will be diverted into the circuit of the electro-magnets which work the ratchet wheels of the indicating and printing instruments. The remaining portion of the current which still traverses the line wire is sufficient to retain the armatures of the transmitting magnets when the instruments are stopped, by depressing one of the finger keys, the line circuit is broken, the armature of the transmitting instrument falls back and breaks the circuit of the electro-magnets which work the ratchet wheels, and on their armatures falling back the circuit of the hammer magnet is completed, and a continuous current of electricity from the part or the whole of the battery passes round the hammer magnet and causes the blow to be struck.

The form and construction of the translating instrument may be greatly varied. Instead of using an electro-magnet and armature, two electro-magnets may be employed or an electro-magnet and a steel magnet, or a magnet and a coil, or two or more coils, or spirals or various other combinations. Thus the apparatus shown in Figs. 14–17 may all be employed for that purpose.

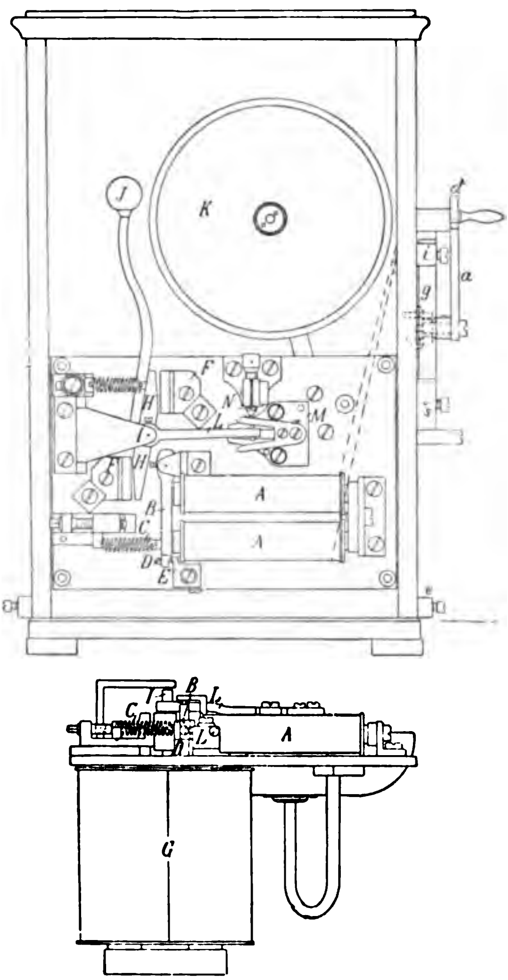
I wish it to be understood that I do not claim generally the use of a translating instrument for completing the circuit of a local battery, but only when such instrument is connected with a self-acting telegraph instrument, so that the circuit of each instrument is made and broken by the action of the other instrument. This reciprocal action of the two instruments enables me to work a self-acting telegraphic apparatus with great rapidity by means of a local battery, or by a separate circuit from the same battery which is connected with the line wire.

VII. Alarums.

In constructing alarums, I employ self-acting instruments, made on the same principle as the indicating and printing instruments above described. The oscillating lever, which is worked by the

electro-magnet, carries, in place of a click, a hammer, which strikes a rapid succession of blows upon a bell. These alarums

Fig. 28.

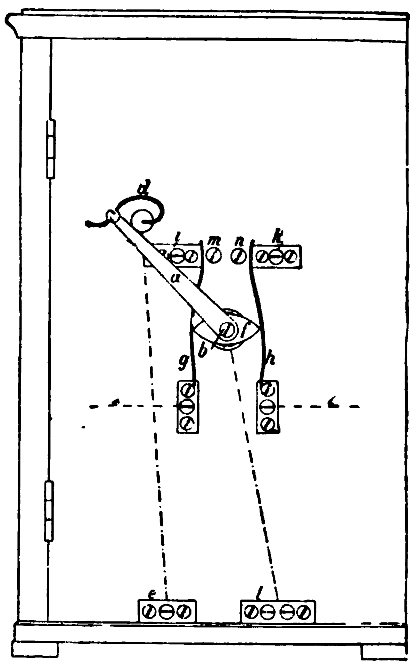


may be worked directly by the currents traversing the line wire, or indirectly by means of the translating instrument with reciprocal action, as already described. They may also be worked

by means of a translating instrument without reciprocal action. An arrangement of this sort is shown in Fig. 28. A is an electro-magnet, with its armature B, which is kept away from the magnet by the spring C, and rests against a stop D; a metallic contact piece E, is placed almost, but not quite, in contact with another contact piece on the armature. This forms the translating instrument, the armature B and contact piece E being included in the circuit of a local battery, which circuit is completed by the slight motion of the armature towards the magnet producing contact at E. F F are the two poles of an electro-magnet G; and H is its armature, turning on the centre I. This armature carries the hammer J which strikes the bell K when the armature is attracted by the magnet. The armature also carries an arm L, provided with the two ivory studs, which strike against the fork M and shift it backwards and forwards. When at rest, the fork is in contact with the metallic point N; one of the wires of the local battery is connected to the contact piece E, and the other wire is connected to the coils of the magnet G, and thence to the point N. The fork M is in communication with the armature B. This instrument may be used with great advantage at intermediate stations, to inform them of the conclusion of a communication which has taken place between two stations on opposite sides of the intermediate station, and to warn the attendant at the intermediate station to introduce his indicating or printing instrument into the circuit. For this purpose the coils of the magnet A are introduced into the circuit of the line wire whenever the signalling instrument is withdrawn, and the spring C is so adjusted that the armature B is not put in motion by the short intermittent currents which work the signalling apparatus at the two stations which are in communication with each other. When the operators at those stations have completed their communication, they both depress a button provided for that purpose in their respective instruments, by which their instruments are excluded from the circuit of the line wire, so as to send a continuous current of electricity through the line wire, and through the coils of the magnet A at each of the intermediate stations. The effect of this continuous current will be to attract the armature B, and keep it in contact with the piece E as long as the current passes. The circuit of the local battery is thus completed and the armature H is attracted and a

blow struck on the bell K. At the same time the motion of the arm L drives the fork M away from the point N, and thus breaks the circuit of the local battery, and the hammer falls back from the bell. The fork is now thrown against the pin N, and the contact restored, when the armature H is again attracted, and the bell thus continues to ring at each intermediate station as long as the

Fig. 29.



before-mentioned buttons are depressed. The attention of any particular station may be called by means of a previously arranged code of signals; thus ringing once for a short time may serve for one station; ringing twice in succession for another; ringing once for a short space of time, and once for a longer space of time, may serve for another station, and so on. By this means a code of audible signals may be employed in place of a code of visible signals.

Fig. 29 represents a front view of the commutator, by means of

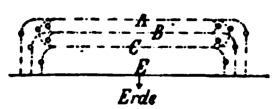
which the above described alarums and the indicating or printing instruments are introduced and cut off from the circuit. *s t* are the line wires passing in either direction from the intermediate station. These wires are respectively in connection with the springs *g h* which are capable of moving between the pieces *i k* and the pins *m n* which are all made of metal. A lever *a* turns on the centre *b* and carries a piece of ebony or other non-conducting substance *f*, of the form shown in the drawing. The end *c* of the lever *a* may be brought in contact with the spring *d* or may be depressed so as to bring the longest diameter of the piece *f* into a vertical position. The ends of the coil of the magnet A, Figure 28, are connected to the pins *m* and *n*, so that when the lever *a* is depressed the course of the current is from the line wire *s* through the spring *g* and pin *m* to the coils of the magnet A, and thence to the pin *n*, spring *h*, and line wire *t*. The piece *i* is in connection with an indicating or printing instrument and battery, from which a connection is made to the screw *l*, which is in connection with the lever *a*. The piece *k* is connected to a similar instrument and battery, from which a connection is also made to the screw *l*. Lastly the spring *d* is connected to earth through the screw *e*. If the lever *a* be now placed in the position shown in the drawing, the springs *g* and *h* will leave the pins *m* and *n* and come in contact with the pieces *i* and *k*. The circuit is now through the line wire *s*, spring *g*, and piece *i* into one telegraphic instrument, and thence through the screw *l*, lever *a*, and spring *d* to the earth, and back to the station from which the line wire *s* proceeds. Another circuit is formed by the line wire *t*, spring *l* and piece *k*, with the other telegraphic instrument, through the screw *l*, lever *a*, and spring *d* to the earth, and back to the station from which the line wire *t* proceeds. The intermediate station is thus converted into a terminal station for both line wires *s* and *t*, and has the power of communicating with the stations in each direction independently. If it be required to exhibit at the intermediate station signals which are passing between two other stations it may be effected by depressing the lever *a* a little from the position shown in the drawing, and thus breaking the connection between the screw *l* and the earth, when the current will pass through and exhibit signals at both the instruments at the intermediate station.

VIII. Combination of Several Line Wires.

Hitherto for each line of telegraphic communication, at least one line wire has been required, and the earth is generally used to complete the circuit. When more than one line wire is established between two stations, I am enabled with my instrument to work as many telegraphic instruments as there are pairs of different lines to be made, counting the earth as one line. Thus with two wires, which with the earth give three lines of communication, I am enabled to work three instruments; with three wires I work six instruments, and so on.

Fig. 30 is a diagram of the mode in which three wires A, B, and

Fig. 30.



C, are connected with each other and with the earth for working six instruments at each end of the line, which are represented by small circles. The circuits thus obtained are AE, BE, CE, AB, AC, and BC. This arrangement of the line wires cannot be adopted with all descriptions of telegraph instruments, but only with those whose efficient working is not prevented by a considerable and irregular increase and decrease of the strength of the current. Each instrument should be provided with a separate battery, and it is further necessary to include within the circuit, together with each battery, something to cause a strong resistance to the electric current, for the purpose of decreasing its irregularity.

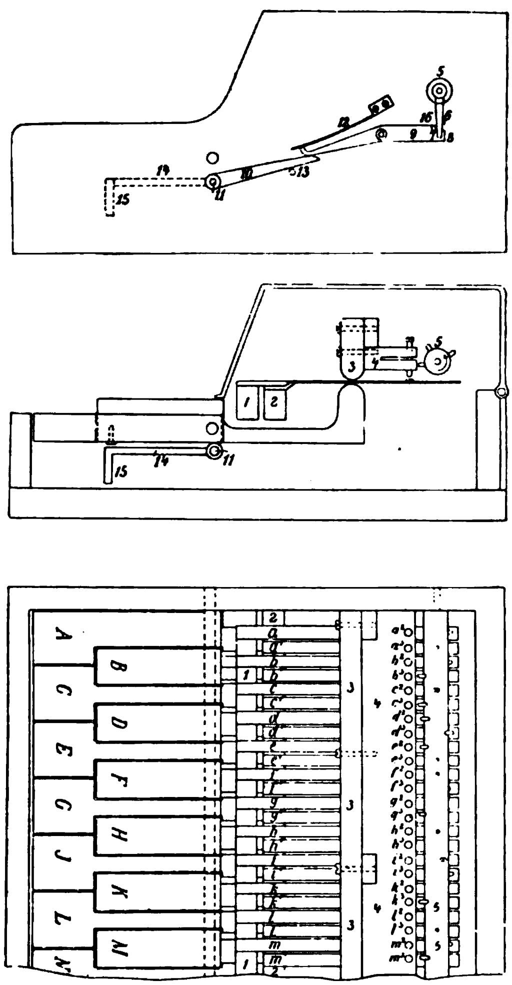
IX. Keyboard for giving Signals by a Succession of Elementary Signals.

Another part of my invention consists in an improved arrangement of needle telegraphs and chemical telegraphs, and generally of those telegraphs in which letters and signals are given by a succession of two or more conventional signs.

Hitherto great skill has been required to work these telegraphs

by hand with the maximum degree of rapidity and certainty of which they are capable. I have rendered that skill on the part of

Fig. 31.



the operator and the uncertainty attending it unnecessary by the introduction of keys, which are marked with the letters of the

alphabet, and which require simply to be pressed down in order to produce the combination of elementary signs which are understood by the receiver of the message at the distant station.

Fig. 31 represents a plan, side view, and section of my apparatus. It consists of a series of keys A, B, C, &c., and as many pairs of springs a, a^1, b, b^1, c, c^1, &c., each pair being capable of being raised when the corresponding key is depressed. That part of the key which comes in contact with the springs is of ivory or other non-conducting material. The two springs, which form a pair, are fixed upon separate metallic bars, 1 and 2, which connect the springs a, b, c, &c., to the earth and the springs a^1, b^1, c^1, &c., to the line wire. The height to which the springs can be raised is limited by a bar, 3, of wood or other non-conducting material. A metallic bar, 4, is fixed parallel to this bar, and is connected to one, say the positive, pole of a galvanic battery. This bar carries as many perpendicular metallic screws a^2, a^3, b^2, b^3, c^2, c^3, &c., as there are springs a, a^1, b, b^1, c, c^1, &c., so that, by pressing down any one key, a connection is made from one pole of the battery to both the earth and the line wire. The places of contact between the springs and screws are formed of the metallic alloys already described. A metallic cylinder, 5, is mounted on an axis, and carries a series of metallic pins on its periphery, which, when the cylinder revolves, depress during short intervals of time the one or the other of a pair of springs, which are raised by the pressing down of one key. The cylinder 5 is connected to the opposite or negative pole of the battery, and when by its revolution it depresses the spring b, the contact between that spring and its screw b^2 is broken, and a circuit is established from the positive pole of the battery, through the spring b^1, the line wire and the receiving instrument at the distant station into the earth, thus causing an elementary signal to be given, and from the earth through the spring b and the cylinder 5 to the negative pole of the battery. If in place of depressing the spring b the spring b^1 is depressed, the current will pass through the line wire in the opposite direction, and thus an elementary signal of an opposite description is produced at the receiving instrument. The cylinder 5 receives its rotary motion by means of clockwork, which is regulated by a fly or by a disc of iron rotating before the poles of a horse-shoe magnet. Instead of

clockwork an electro-magnetic machine may be used for this purpose, which may at the same time serve to produce electro-magnetic currents by induction, which are sent through the line wire in place of the current from the battery. The axis of the cylinder 5 carries on one end an arm, 6, Fig. 31, which is bent backwards in the form of a hook at 7 ; when the instrument is in repose, this hook rests against a stop, 8, on the lever, 9, the end of which is made to bear on the lever, 10, turning on the axis, 11, by means of the spring 12. The lever 10 rests against a pin, 13. On this axis are fixed two or more arms, 14, shown by the dotted lines. These arms carry a bar, 15, which extends from one end of the instrument to the other, so that the depressing of any one of the keys depresses the bar 15, raises the lever 10, depresses the stop 8 and releases the cylinder 5, which immediately revolves. When it has nearly completed a revolution the hook on the arm 6 is arrested by the stop 16 on the lever 9. By the revolution of the cylinder a succession of contacts will have been made between the pins on the cylinder and one or both of those two springs, which have been brought into action by depressing the key, and thus a certain succession of elementary signals of the same or opposite directions will have been produced in the receiving instrument at the distant station, which succession of elementary signals may represent the letter marked on the key which has been depressed. On releasing the key the stop 16 on the lever 9 is raised by the action of the spring 12, and the arm 6 moves forward through a short space, when it is arrested by the stop 8, against which it rests, until another key is pressed down. In order to produce currents of longer duration by this instrument I fix upon the cylinder several pins in close succession, or one broad pin. The receiving instrument at the same station is included in the circuit and gives the same indications as the one at the distant station. The pin 13 is of metal and is connected to the bar 2, whilst the lever 10, which is also of metal, is connected to the bar 1. The line wire is thus placed in direct communication with the earth when the instrument is at rest, and the receiving instruments remain included in the circuit. The circuit is thus always in readiness to receive a communication from another station. It will be readily seen that instead of producing the signals by means of two springs and one cylinder with pins, two cylinders may be employed with one spring

for each key. If currents in only one direction are required, one cylinder and one key to each spring are sufficient, a cylinder with insulated pins may be used, in which case the springs are placed close to it, so as to be depressed by the pins and thereby brought into contact with the end of the depressed key, which is then made of metal and connected with one of the poles of the battery. The cylinder may also be provided with more than one arresting lever, and be so arranged that the signals composing a letter may be produced by only a part of a revolution of the cylinder.

X. Underground Line Wire.

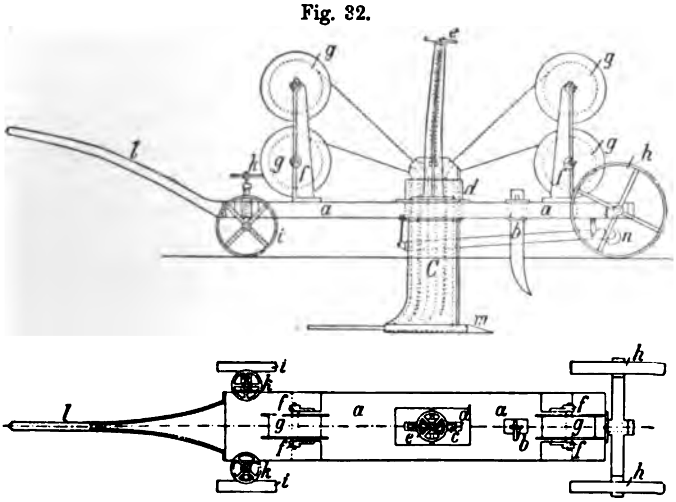
Hitherto where coated line wire has been used for telegraphic purposes, either it has been suspended in the air (as in passing through tunnels) or it has been inclosed in lead or iron tubes, and laid either above or under the surface of the ground, or lastly, it has been laid without any metallic protection in open trenches which were made and afterwards filled with earth in the usual manner. The difficulty of insulating underground wires and other reasons have led to the extensive adoption of the practice of suspending the line wires in the air. The introduction into commerce of the substance called gutta percha has however of late given great facilities for the insulation of underground wire, by employing a wire coated with this substance. Still, the expense of laying such wire in the ground, together with defects in the insulation arising from flaws in the coating and other causes, have hitherto restricted its use in this country, although it possesses considerable advantages in some respects, particularly as regards its being almost entirely free from the interruptions caused in suspended line wires by lightning and atmospheric electricity.

The object of this part of my invention is to remove the various difficulties in the way of employing underground line wire. My improvements in imbedding coated line wire in the ground, consists in the application of certain implements for that purpose, which are forced through the ground by means of steam or animal power, whereby a considerable saving of manual labour is effected.

Fig. 32 shows an elevation and plan of an instrument partaking of the nature of a mole plough, which I make use of for this purpose. It consists of a strong frame *a*, a coulter or cutter *b*, and

the principal hollow cutter or mole *c*, which works in a guide *d*, in the frame *a*, and may be raised or lowered into the ground by turning the wheel *e*, on an upright screw which is supported in a standard frame. On the frame *a*, are fixed brackets *f f f f*, which support the drums *g g*, on which is wound the coated wire which is to be deposited in the ground. The frame *a* is supported in front by a pair of wheels *h h*, the axis of which is fixed to the frame by a swivel joint, and in the rear by a pair of wheels *i i*, which may be adjusted in height individually by means of screws

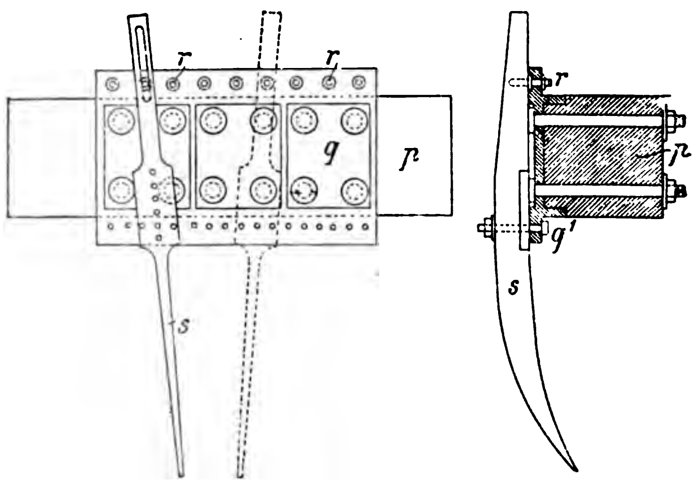
Fig. 32.



k k. A tail *l*, is provided for the purpose of directing the instrument through the ground. The mole *c* is composed of two plates of wrought iron or steel, which are riveted together with intervening strips of metal as indicated by the dotted lines, which form separate guides for the coated wires into the ground. The front edge of the mole blade is made angular, and the mole itself has a shoe of steel or chilled cast iron *m*, to facilitate its passage through the ground. In order to diminish the friction of the wires in the mole, small rollers at its mouth and along its sides may be provided. This instrument is used in the following manner :—As many separate wires as are intended to be laid are threaded through the guides in the mole. A hole is made in the ground at the

commencement of the line to receive the mole, and the ends of the wires are fastened to a post or otherwise. The instrument is then drawn forwards by means of crabs, which are fixed at some distance and which may be worked either by animal power or by a portable steam engine; or if the ground is of a loose description, the plough may be drawn along by horses or oxen without the aid of fixed machinery. The draught chain or rope is attached to the hook *n*, which is freely suspended from the frame *a*, and transfers the power to the mole itself. If the ground is hard, I make use of a common double plough to precede the instrument just described,

Fig. 33.



or I loosen the ground by merely cutting through it with a deep coulter. Another plan is to cut a trench of half the required depth, and then to pass the mole plough along at the proper depth.

In depositing line wire in the ground along railways, I prefer to employ the power of a locomotive engine. A strong beam *p*, Fig. 33, is fastened across the engine-frame. To the end of this beam, which projects beyond the ends of the sleepers, a frame of cast iron *q*, is fixed, which is provided with a series of studs *r r r* along the upper flange, and a series of holes along the lower flange. A strong coulter *s*, is fastened to this frame in any desir-

able position, as will be seen from the drawing, by means of a single bolt q^1 which in case of undue resistance in the ground, on account of a stone or other impediment, gives way and allows the coulter to stop; the impediment being removed, the engine is again brought up to the coulter, and connected to it by means of a fresh bolt.

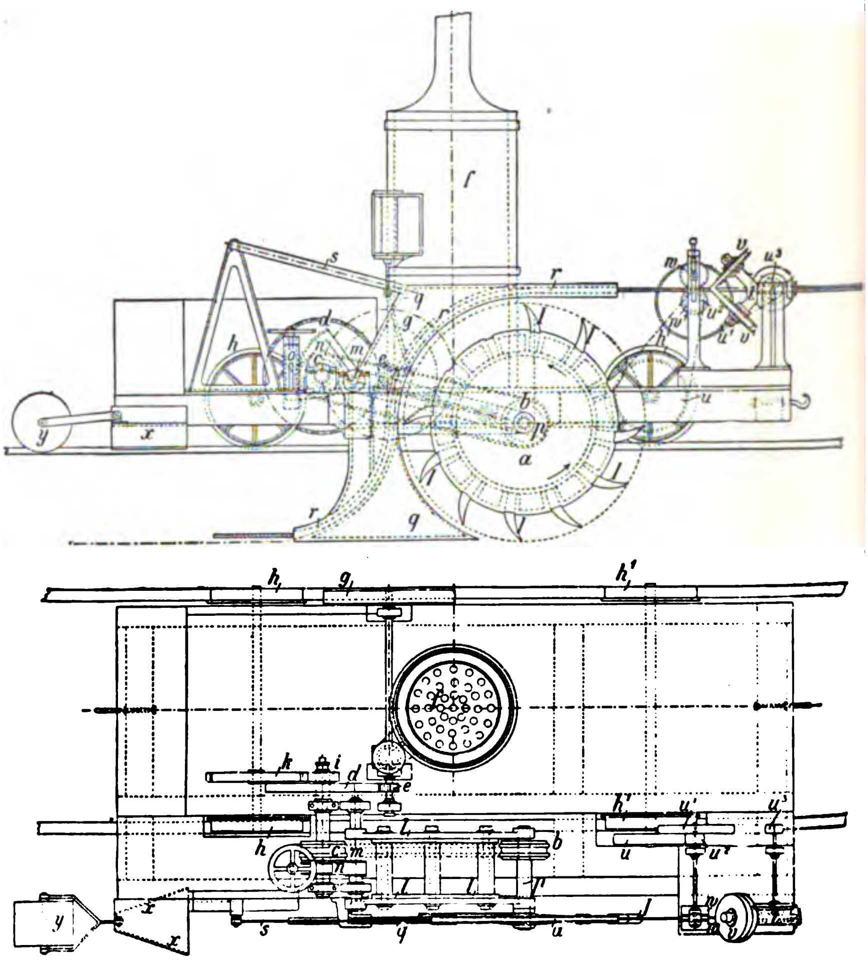
The first coulter may be followed by a second and even a third, going to a greater depth than the first, and finally it may be followed by a mole for depositing the wire or wires, similar to the one above described, but fastened with its own frame to that of the engine, in such a manner that whenever the ground presents an undue resistance the mole frame shall be detached from the engine by the giving way of a bolt or spring catch, or any other similar contrivance, as is well understood. In places where the ground is frequently intersected with large stones, rocks, or the roots of trees, it is sometimes desirable to complete an open trench, in which the line wire is deposited in the usual manner, or with a coating of sheet lead, as hereinafter described. In using the power of a locomotive engine for this purpose, I first pass a coulter through the ground in an oblique position, as represented in Fig. 33, and afterwards in the position shown by the dotted lines in Fig. 33. By this means a prismatic body of earth is separated, which is removed to the surface by a lifting tool similar in form to a double plough, which is also attached to the same or another engine.

The same process may then be repeated with deeper coulters and ploughs, until a trench of sufficient depth is completed. In this operation frequent recourse is had to manual labour.

In dry and chalky soils an instrument similar to that shown in Fig. 34, may be employed. It is here represented as adapted for laying line wire by the side of a railway. It consists of a large disc *a*, which is formed of wrought iron, and carries on its periphery strong teeth or cutters 1, 1, 1, 1. The axis of this disc carries a chain pulley *b* by which it is turned round in the direction of the arrows, the motion being derived from another chain pulley *c*, which is driven by means of the wheel *d*, and pinion *e*, which last is set in motion by a small steam engine attached to the upright tubular boiler *f*. The crank shaft of this engine carries a small fly-wheel *g*, which however may be dispensed with if two

steam cylinders are used, as is well understood. The frame which supports the engine and machinery rests upon four wheels

Fig. 34.



h, *h*, h^1, h^1, which run upon the rails of the railway. The wheels *h*, *h* are made to revolve slowly by means of a pinion *i*, which gears into a wheel *k* on their axis, and the carriage is thus made

to advance slowly by the friction of the wheels on the rail. The cutting wheel *a* is supported by its axis in a movable frame *l*, with its fixed centre *m*, which carries a toothed segment *n*, gearing into an endless screw *o*, by turning which the wheel *a* may be lifted clear out of the ground. When in its lowest or working position, the axis of the wheel *a* finds a direct support on the principal frame, in an open bearing at *p*. Immediately behind this wheel follows a flat wrought iron frame or sheath *q*, which is made a little narrower than the cutting teeth, in order to slide freely through the ground, and which conducts the coated wire or wires into the ground through an internal channel *r*, *r*, *r*. The framing *q* is supported on the axis of the cutting wheel, with which it is raised and lowered, being always maintained in its upright position by a guide rod *s*.

In sandy or stony soils I prefer to envelope the insulated wires with thin sheet lead, which is accomplished by the machine itself in the following manner :—A hollow axis *t* is made to revolve with a velocity depending on the advancing motion of the machine, by means of a pair of bevel wheels and the strap pulleys u, u^1, u^2, u^3. This axis is provided with two studs in an oblique position, and opposite to each other, which carry the two pulleys or bobbins v and v^1, containing coils of lead strip. The line wires are laid out on the ground in advance of the carriage, and are conducted through the hollow axis *t* and the channel *r*, *r* into the ground, but are in their passage lapped round with the two strips of sheet lead in a regular helical form. Two grooved rollers w and w^1 serve the double purpose of pressing the lead firmly in contact with the inclosed coated wires, and of drawing them into the machine, so as to prevent them from being stretched too tightly in the ground, one of the rollers *w* being driven in the direction of the arrow by the strap pulley u^2 on its axis. In order to level the ground again, after the wires are deposited, I attach two slanting boards *x x* to the back of the carriage, which are followed by a heavy cast-iron roller *y*, as will be readily understood from the drawing.

The rate of advance of the cutting-wheel may be regulated according to the nature of the ground, by changing the proportion between the pinion and the wheel, for which purpose intermediate gearing may be applied. If the machine is to be moved freely along the rails, the cutting-wheel *a* is raised by means of the end-

less screw *o*, and the pinion *e* is slipped back on its shaft, whereby the driving wheels are liberated. An additional pair of driving pulleys may be provided to connect the driving wheels directly with the crank shaft of the engine, to run the carriage quickly from place to place, by the power of the engine itself.

It will be seen that a machine of similar construction to the one just described may be used also on common roads. The advance of the carriage may, in that case, be effected with a greater degree of certainty by means of a rope, which is fastened in advance of it, and wound gradually on a cylinder. In all cases means must be provided to stop the cutting wheel, in case it meets with an undue resistance in the ground, either by pulling up the engine, or by the wheels slipping on the rails, or on the ground, or by a weaker portion of the rope or an axis giving way, or by any other suitable means.

Either of the instruments herein described for depositing the line wires in the ground, may also be so arranged as to be applicable below water. For instance, in crossing rivers or narrow branches of the sea, the plough, Figs. 32 and 34, may be drawn through by means of a cable, which is wound on a crab on the shore. A diver should be in attendance to remove or avoid the impediments which the instrument may meet with. In crossing sheets of water of considerable breadth the cable may be attached to the stern of a steamboat, which at the same time carries the coils of insulated wire. If a revolving cutter is used, I place the driving machinery and the apparatus for covering the wires with sheet lead on board, and transmit the motion to the cutting wheel by means of a diagonal shaft.

In preparing line wire suitable for being laid underground I use a combination of gutta percha and sulphur, with which the wire is coated and insulated throughout its length. I employ any of the well known processes for the purpose of combining the gutta percha with the sulphur. I prefer to employ gutta percha which has been entirely freed from water, and to mix it mechanically with sulphur, in the state of very fine powder by means of rollers, and then to effect their chemical combination by heating the mixture in a steam chamber. This combination of gutta percha and sulphur has the advantage of great hardness, and consequently is not so much exposed to external injuries; it has,

moreover, the property of not being converted into a hydrate when exposed for a long time to the action of water, as is the case with pure gutta percha, which in consequence loses by degrees its insulating power; on the other hand, the sulphur in the sulphuretted or vulcanized gutta percha has an action on the copper wire, and forms on its surface a non-insulating substance; but this action takes place only during the coating of the wire, when the insulating material is warm, and can be made very insignificant by using no excess of sulphur and by heating the substance only moderately. After the gutta percha has cooled again, this action of the sulphur on the copper ceases.

The coating of the wires with this prepared gutta percha is done by pressure. The machines hitherto used for this purpose are defective in many respects, the wire was seldom in the centre of the gutta percha, th thickness of the coating varied on different parts of the wire, and the insulation was imperfect owing to air bubbles and other defects which prevented the solidity of the gutta percha.

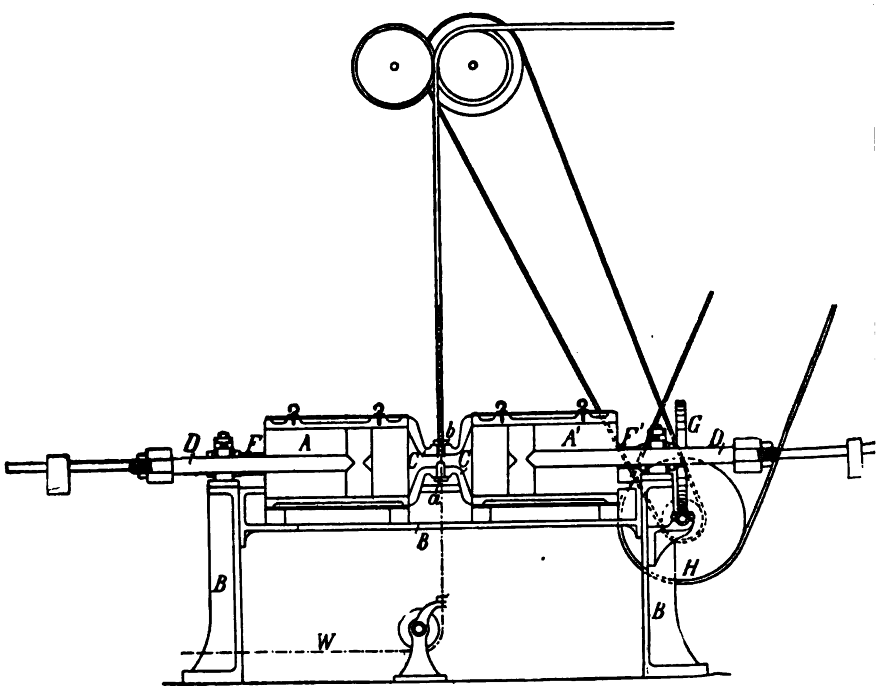
I will now describe my improvements in coating the wire and in detecting flaws and imperfect insulation in the coated wire.

My machine for coating the wire differs especially from other machines for the same purpose in the application of two cylinders for pressing the gutta percha from two opposite directions, so as to prevent a one-sided pressure on the wires, which are situated between the two cylinders, and also in the fact of the cylinders being movable so that they may be taken out when empty, and replaced by others, which are filled with gutta percha.

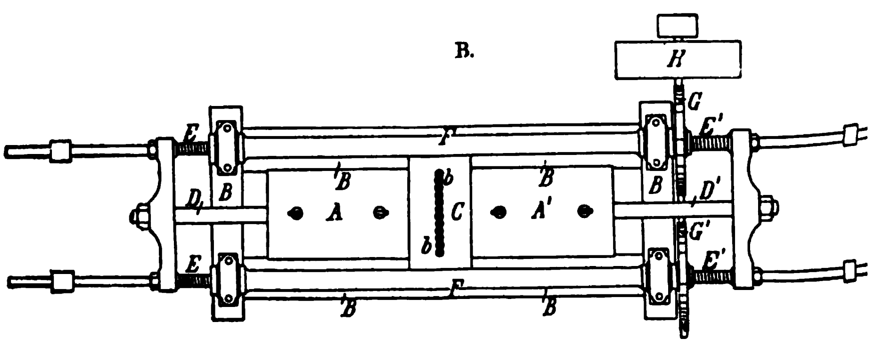
Fig. 35 represents a vertical section and plan of the machine, A and A′ are the cylinders, which rest on the frame B, with their open bottoms in contact with the central piece of the machine C, which is firmly fixed to the frame B. The central part of the piece C forms a shallow passage of the same breadth as the cylinders, which are thus in communication with each other. The passage is perforated by a row of twelve vertical holes through its upper surface, and a similar corresponding row of holes through its lower surface. In these holes are placed short perforated cylindrical pieces of metal or bushes *a* and *b*, the holes through the lower ones *a* being of the size of the uncovered wire, and the holes through the upper ones *b* being of the size of the coated wire. For the

Fig. 35.

A.



B.



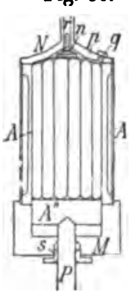
purpose of guiding the wires W exactly through the centre of the upper holes, the lower bushes *a* are made conical at their upper

ends, as shown in the drawing; the conical part may be of steel or a hard stone. The lower ends of the upper bushes *b* are made conical on the inside so that a small circular space is left between the inside of the upper hollow cone and the lower cone. The gutta percha, which, by the action of the pistons in the two cylinders A, A′, is pressed from both sides into the hollow passage of the central piece C, enters the circular spaces above mentioned, and passes, with the wire in the centre of it, through the upper bushes. The wires being equally pressed on both sides will have no tendency to get out of the centre of the gutta percha or to produce friction against the sides of the holes in the lower bushes *a*, which will, therefore, not be worn so much as when pressure is on one side only. The simultaneous movement of the two pistons is secured by means of the right and left handed screws E, E and E′, E′, which are placed parallel with the piston rods D and D, and connected with them, as seen in the drawings. By turning the wheels G, G′, the hollow cylinders F, F′, which are provided with nuts at their ends, are turned round, and the screws E, E, E′, E′ are drawn into the hollow cylinders F, F′, and the pistons approach each other with equal velocity; the two wheels G, G′, are turned by means of an endless screw, to which is fixed the drum H, which is driven by a strap; the driving motion is so arranged that it may be reversed and the piston rods drawn back at an increased velocity; the pistons are not fastened to their rods, but remain in their position when the rods are moved back. By means of a crane the cylinders A, A′ may be raised from their position when empty, and replaced by others filled with gutta percha. The operation of coating the wire may then be continued. The cylinders are surrounded by a steam jacket, which prevents the cooling of the gutta percha; the wires are straightened and wound on drums, and are guided through vertical holes placed at some distance below the bushes *a*. After the wires have issued, coated with gutta percha, from the upper bushes *b*, they are carried upwards through the air for twenty or thirty feet and pass between wet rollers covered with felt or other soft material. In this way a uniform thickness in the coating of the wire is produced.

When a very thick coating is employed, I cause the coated wire to be guided still higher and to pass between several pairs of similar rollers. As air-bubbles, which happen to be in the gutta percha,

are very injurious to its insulating power, great care must be taken in filling the cylinders, lest any air should be included in the gutta percha. For this purpose I prepare a number of cylinders of gutta percha of small diameter and rather shorter than the cylinders A, A′, by means of rollers, or by squeezing the gutta percha in a warm state through a die by means of a cylinder and piston, or otherwise. The piston of the empty cylinder A or A′, which has been removed from the machine, is forced nearly out of the cylinder, which is then placed upon the block M, Fig. 36, and is filled with the small cylinders of gutta percha and covered with the lid N; in the centre of this lid is a heavy valve *n*, opening inwards, under which is a curved plate or dish of sheet iron *p*. An opening at *q* is capable of being closed by a cap or slide; a passage *r* leads to an air-pump; P is a strong rod working through a stuffing-box *s*; the joints are all made air-tight, and the air is then exhausted by means of the air-pump; the valve *n* is kept open by its own weight. When a good vacuum has been obtained the piston A″ is forced up by means of the rod P, and the gutta percha squeezed into one mass, the cylinder being kept warm by a steam jacket, the gutta percha presses against the dish *p* and closes the valve *n*, thus preventing the passage from becoming obstructed by gutta percha. When the mass is well consolidated the hole *q* is opened and the piston is advanced to a certain predetermined distance, so that the cylinder is thus always filled to the same mark. The apparatus is now disconnected, and the gutta percha which has filled the hole *q* is trimmed off. The cylinder charged with gutta percha is now placed in the machine, and the convex surface of gutta percha being pressed against the flat surface left by the previous operation, squeezes out the air and unites the two surfaces in a sound and effectual manner.

Fig. 36.



Notwithstanding every precaution in coating the wires it seldom happens that a great length of wire can be at once prepared in a perfect state. Small pieces of dirt or other foreign matters, and air-bubbles and small injuries invisible to the eye are generally present and render the insulation imperfect. A small degree of imperfection in a new line is of no consequence, but the defective

places generally become worse in the course of time, and still more so when the gutta percha has not been freed from its water. I therefore test the perfection of the insulation before employing the wires. A large quantity of the coated wire is immersed in a vessel of water, the two ends of the wire being kept out of the liquid. One or both ends of the wire are connected to one pole of a galvanic battery, and a wire is carried from a metallic plate immersed in the liquid to the coils of a very delicate galvanometer, consisting of an astatic needle surrounded with from five to ten thousand convolutions of wire from which a connection is made to the other pole of the battery. If the needle of the galvanometer is not deflected the insulation is perfect; if the needle is deflected it shows that the insulation is imperfect, and I then proceed to ascertain the position of the defect or defects in the following manner :—The wire is wound upon a drum or reel, and its end is placed in contact with the metallic spindle of the drum from which a connection is made by means of a spring and wire to one end of the induction coils of a magneto-electric or electro-magnetic machine for giving electric shocks. The other end of the induction coil is brought into contact with the body of the workman. The other end of the coated wire which is to be tested is passed under a pulley immersed in a vessel of water and then attached to another drum or reel, on which it is wound by turning a handle under the control of the workman. While the wire is thus passing through the water the workman dips his finger into the water of the vessel, or into another vessel communicating with it. As long as the insulation is perfect in that part of the wire which is passing through the liquid the workman will feel nothing, but the moment an imperfectly insulated part of the wire enters the water the circuit of the induction coils is completed from one end of the coils through the coated wire, the water, and the body of the workman, to the other end of the coil, and the workman will receive an electric shock, when he will immediately stop the machine and mark the defective place. When all the defects have thus been ascertained they are repaired by warming the place and winding it round with warmed strips of gutta percha. When all the defects have been thus repaired, the wire is tested again, and if it should still be found to be imperfectly insulated it should be rejected, as the fault will

then be owing to the badness of the quality of the gutta percha itself.

In some cases it is advantageous to employ some additional covering to protect the underground insulated line from external injury. Tubes of iron or lead have sometimes been used for this purpose, but are inconvenient in many respects, particularly in making joints and repairing defects. In place of tubes of lead or iron I employ strips of sheet lead, which I place round the coated wires, either in a spiral direction, as described in reference to Fig. 34, or I bend a long strip of sheet lead into the form of a gutter and lay the wires in it, and then fold the lead over the wires so as to completely surround them. The operation may be performed either on the line, as the wires are laid, or previously.

Underground insulated line wire may be compared to a Leyden jar of which gutta percha forms the non-conducting material, which is coated on its inner side with the metallic line wire, and on its outer side with the moisture of the air or sea. On passing a current through such a line wire a certain amount of the electric fluid goes to charge the jar, and this charge will again discharge itself through the telegraphic instrument at one end of the circuit, if the circuit is broken in the instrument at the other end, whereby one instrument may sometimes make two strokes while the other instrument makes but one. I remedy this defect by establishing a continuous connection between the earth and the line wire at each end of the circuit by means of a thin covered wire of German silver, or any other material which offers a great resistance to the electric current but still allows a sufficient quantity to pass to discharge the line wire. The same defect in underground line wires is, to some extent, remedied by distributing the battery-power over many different stations along the line, all the batteries forming part of the same circuit.

SHORT ACCOUNT OF THE EXPERIENCE GAINED WITH UNDERGROUND CONDUCTORS ON THE PRUSSIAN TELEGRAPH LINES.*

THE Committee existing in Berlin up to the spring of 1848 for the preparation of telegraph arrangements in Prussia had from a careful consideration and knowledge of the cause of the great uncertainty in electric telegraph service already existing to a great extent in England and America, especially directed their attention to the improvement of the conductors. They recognized that the overhead lines hitherto alone used would always prevent the attainment of a telegraphic communication which should be thoroughly and at all times safe, as being faulty in principle, and that only good underground conductors rendered the attainment of this object possible.

In the summer of 1847, two wires, half a mile long, insulated with gutta percha were laid by their orders at different depths on the Anhalt railway. The covering of these wires with gutta percha was effected by means of fluted rollers in a very imperfect manner. It soon appeared that it was impossible by this means to produce perfect and durable insulated wires. The seams connecting the gutta percha strips, out of which the covering was formed, could not be made tight, and after some time lost their solid coherence. A machine by means of which the gutta percha could be formed round the wire in a solid mass and without seam, was constructed to obviate this inconvenience, and already in the spring of 1848 was produced in model and tested.† It had not been possible to collect experience as to the necessary depth for laying the wires on account of the shortness of the time. Gutta percha itself and its properties were then only slightly understood ; it was hardly known that there were different kinds of it, and ignorance naturally existed as to the causes of its decay, and the disadvantageous properties of the bad sorts. This was the actual position of the experiments, when the political events of the year

* 1851.

† Fig. 37 is a drawing of this model still preserved in the Berlin Post Office Museum.

1848 necessitated the prompt erection of the telegraph lines

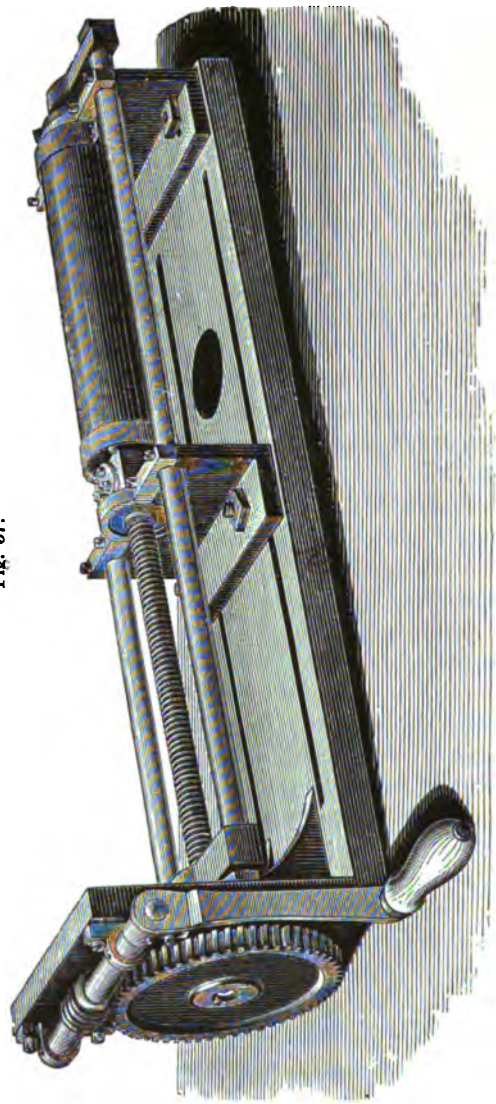


Fig. 37.

from Berlin to Frankfort-on-the-Maine and to Aix-la-Chapelle. As the lines already constructed with such imperfect appliances

had given, on the whole, so satisfactory a result, and as the defects still existing appeared easy to overcome by improved means of manufacture, the Committee pronounced in favour of underground conductors insulated with gutta percha, and in consequence these lines were to be laid down in this way. It must be confessed that this resolution was certainly somewhat risky as matters then stood; nevertheless, the great advantages which the use of good underground lines promised, the results of the experiments made which were generally so favourable, as well as the troublous times which seemed to endanger overhead lines too much, justified the decision arrived at. It was, however, unfortunate both as regards these works, and the system of underground wires in general, that these first lines had to be constructed in a great hurry, and that there was neither time for improving the manufacture of the wires, nor was it possible properly to make use of the experience gained in carrying out the work.

It was determined to use gutta percha combined with sulphur, vulcanized gutta percha as it is called. The reasons for this choice were partly the greater hardness of this combination, partly its known greater durability in the open air. But it had only been known for a short time, and experience was therefore wanting as regards its proper production as well as knowledge regarding the necessary proportions for mixing it. As a rule, the material was too much vulcanized, worked at too high a temperature, and to a certain extent the gutta percha was not previously sufficiently freed from water. The evils thus arising manifested themselves perniciously, especially in the earlier lines.

With excess of sulphur and too high a temperature the copper combines with the sulphur, the copper sulphide thus formed penetrates the gutta percha which lies nearest the wire, and forms with it a mass of a dark brown appearance which conducts electricity, and in the oldest conductors is often a quarter of a line thick.

The quality of the wires would, however, have been less injured hereby, if the wire had lain in the middle of the gutta percha, if the above mentioned layer consisting of non-insulating gutta percha had been everywhere surrounded by good material, and if the material had always been quite freed from water.

But this was unfortunately not the case throughout. The

factory entrusted with the covering of the wires could not at first succeed in covering the wires with a concentric layer of gutta percha by means of the new machine. Almost all the wires covered at that time were covered more or less eccentrically, and often in parts were only covered with a thin layer of gutta percha. The gutta percha contained besides a quantity of bubbles and hollows, which it was not yet understood how to avoid, and it was still not thoroughly purified and freed from water, and was often, by the use of too high a temperature, changed into a spongy mass afterwards becoming brittle. The good material was often adulterated with worse kinds or spoiled gutta percha. The technical position of the manufacture of the wire was consequently still very low and much experience had still to be gained in every direction. Nevertheless the above mentioned lines had to be finished in the shortest time. It was to be anticipated that the execution would be very imperfect, and this was to a great extent the case.

For the reasons above mentioned, it was only seldom possible to produce perfectly insulated wires. Often the wires were so very eccentric that the non-insulating layer of gutta percha next to the copper wire, reached to the outer surface. Where this was not the case, still the bottom of the hollows and air bubbles was reached. The covering thus partly lost its insulating property and the current passing through the conducting places, when the conductors were subsequently used, decomposed the copper sulphide, and in the course of a few years changed the gutta percha into a loose spongy mass filled with water. The consequence of this was, that the copper wire itself was oxidized by electrolysis, and copper oxyhydrate was formed, which at last burst the covering quite apart, and produced longitudinal rents in the gutta percha, often of very considerable extent. Everywhere where gutta percha mixed with copper sulphide formed the bottom of a hollow in the insulated covering, the same action went on, and there were found in place of the hollows holes reaching through to the wire itself.

If from the beginning only perfectly insulated wires had been used, this phenomenon which was so disturbing, especially on the Frankfort-on-the-Maine line, could not have taken place. Unfortunately wires had to be employed in any condition, and too sharp a control of the insulation was therefore not practicable. Even the

wires at first rejected on account of imperfect insulation were nevertheless used later to a great extent, after they had received a thin covering of gutta percha solution, and were thus somewhat improved for the moment. Of these wires about fifteen miles were used, partly on the Thuringian railway, but chiefly between Berlin and Minden. A considerable number of these were unfortunately used, successively at much later intervals of time, and in this way the original imperfection of the wire manufactured was carried over to many of the later laid lines. The cause of the bad insulation of these wires was not alone due to the eccentric position of the conductor. The cause was frequently the decomposition of the good gutta percha used through too great heating, or through imperfect drying before vulcanization, but partly also the use of gutta percha previously spoiled or adulterated. As regards the influence of the depth at which the wires were laid, there existed as yet no guiding experience ; it was well known that gutta percha only remained completely unaltered when the air was kept out, and then when exposed to air it was changed by degrees into a porous, and in warm positions into a viscous body, but it was not known to what depth a change of air takes place in the body of the earth, and it was sought to reduce the cost of the laying too much by reducing as much as possible the depth at which the wire was laid. The depth of 1½ foot first chosen was, however, too small, for this depth, as experience shows, is often reached by labourers on the railway, and the wire in consequence is easily injured. It was then soon changed to a depth of 2 feet, yet this depth was often not reached, and there are many stretches, especially on the line to Aix, where the line lies hardly a foot below the ground. This line was partly laid in winter during hard frost, and the stretches between Potsdam and Brandenburg, and between Minden and Cologne in particular, were laid in the greatest hurry, which explains the departure from the specification. The laying of the wires in the trenches on the older lines was not effected without frequent injuries to the covering. Besides, the wires were faultily packed, and they were thus frequently injured in transport to the place where used ; the workmen had not gained any practice nor sufficient caution in handling them ; the bad season rendered the work and inspection more difficult, and in consequence of the political agitation then taking place,

many premeditated injuries were done. Under these circumstances, it was explicable that the service of the original lines was not very regular and sure at first. The insulation of the lines was satisfactory, as a rule, shortly after the laying of the line, but got bad by degrees, when the rain had soaked through the ground to the wire. The workmen entrusted during the laying with the search for existing faults, and the repair of the wires, had to be employed on the further work, and the inspection was therefore entrusted in bad weather to inexperienced persons, so that the lines were thus frequently further injured. The underground lines moreover presented many scientifically quite new and unexpected phenomena, which were only overcome by corresponding alterations in the construction of the apparatus after their existence had been perceived.

Frequent disturbance of the service and complete interruption of telegraphic communication occurred later with the lines. The injuries to the wires caused during the laying increased gradually owing to the current, and the insulation thus became worse and worse. A thorough inspection by competent persons some time after the completion of the laying, or in the following summer, would have removed these injuries once for all. But besides the question of cost, the continuous use of the lines, and the greater difficulty of inspection of a single wire, without stopping the correspondence were against it. Hence, unfortunately, it became a practice to examine a line only after the insulation had become so defective that the apparatus refused to work. As in this case, one of the few workmen who were experienced in the matter had to be sent from Berlin to the place of disturbance, some days passed before the damage was remedied, and then only for a short time The line between Minden and Cologne was subject in this way to very frequent interruptions; this line certainly at first consisted almost altogether of new and better made wires, nevertheless, it was laid in a great hurry in rocky ground, and the gutta percha was therefore very frequently injured by blows. The frequent bendings to which the wires were exposed, while they were still in the factory and partly in laying, were often followed by breakage of the wire inside the gutta percha, without these fractures being noticeable from outside. If the covering had consisted of unvulcanized gutta percha, only in a few cases would a current have

passed through the fractured places, and they would have been easily observed during laying, and removed. As already above stated, especially the wires first manufactured at a high temperature, were always surrounded with a conducting covering of gutta percha and copper sulphide; these wires carried the electric current sufficiently well to be able to telegraph through them. Owing to the great resistance which this material opposed to the current, it became heated in use, and thus still further reduced the conductivity of the wire. The strength of the current was therefore subjected to constant and very considerable fluctuations, and the action of the instruments was consequently very irregular. Such broken places were often only observed and repaired after the lapse of some considerable time.

With the lines first laid in which the wire was not laid at a sufficient depth, new injuries frequently occurred. They consisted partly of injuries to the covering of the wires, or in their complete destruction by the men engaged on the railway, but partly also of injury to the covering by rodents. The last kind of injury has in particular given rise to numerous attacks on underground lines. Moles, rats, mice and such like animals burrow the ground as a rule only at a slight depth, because at a greater depth they can get no food. It has nevertheless become apparent that the depth of $1\frac{1}{2}$ foot, and in some cases the depth of 2 feet, did not in every case secure the wires against gnawing. The animals appear usually to make their nests at greater depths. If while thus occupied they find the wire in their way, they generally seek to remove it by gnawing. The very few cases in which wires at two feet have been injured by gnawing would have been easily and entirely obviated by a slight increase of the depth of laying, and by due regard for and security of the places damaged from various causes, as was always the case here. Most of the telegraph lines laid at a depth of 2 feet have not been injured since laying.

Another cause of numerous disturbances of the service on the old lines consisted in such faults as were made in manufacture of the wire, which only made their disturbing influence felt after a certain time.

The necessary consequence of the very eccentric position of the conductor when vulcanized gutta percha is used has already been

mentioned. These phenomena already occurred in the previous year on the older lines and consequently quite recently frequent repairs had to be made, and often whole cores were replaced which were spoilt by the eccentricity of the wires, and had slits in their length. In these wires a hardening or other alteration in the gutta percha was observed only in rare cases, and generally only when the wires lay at a very slight depth and in light dry ground. These rents were only to be found in those places where the eccentricity of the wire was so considerable that the layer of conducting gutta percha referred to lying next to the copper wire actually reached the surface of the covering. Less eccentric places remained quite good.

Already in previous years at several places and especially on the line to Minden, it happened that there were wires in which the gutta percha had lost all its flexibility and elasticity, was traversed by numerous cracks, and in consequence had lost its insulating property to a great extent. This phenomenon is, however, that which most properly calls forth the closest consideration with respect to the use of gutta percha for underground lines. If a special reason for the decomposition cannot be deduced from the circumstances attending the phenomena, if it must be assumed that gutta percha is not durable for any length of time when in the ground in the same way as when in the air, and that a complete although slow change occurs, a death blow would naturally be given to the use of gutta percha for underground lines, and for the time at least also to underground conductors. Fortunately the conclusion that this is not the case can be easily and clearly proved by means of the experience gained. This phenomenon of the hardening and complete change of the gutta percha on both the older lines in the year following their laying was already observed in certain instances, whilst on the lines partly laid in the same year and a little later hardly any similar case has occurred up to now. Certainly in some special cases wires have become unserviceable through eccentricity on the new lines mentioned, but it has almost always been proved, as regards these, that they belonged to an earlier period of manufacture; hitherto no case has ever occurred of a general hardening or toughening of the gutta percha. Most frequently the phenomenon in question has taken place on the line between Berlin and Minden, and in some cases also on the

Thuringian railway. The damaged wires still bear as a rule considerable traces of having been covered with gutta percha solution, although others also exist which were laid without such covering. The wires covered with gutta percha solution, as already mentioned, were rejected partly on account of their being made eccentrically; with many of them, however, the gutta percha was itself spoiled partly before use, partly through injudicious manipulation during manufacture. Gutta percha of that kind becomes in a very short time porous and brittle throughout, and this change takes place it appears even with complete absence of air.

The greatest part of the wires mentioned, besides many others which resisted the slight test of insulation then used, were made from gutta percha imported from England in an already purified condition. Even at that time it appeared probable that this gutta percha, which but seldom furnished perfectly insulated wires, consisted in great measure of hardened or wilfully adulterated material. But as this material so constituted was the only gutta percha in the market, and wires under any circumstances had to be prepared and used, it nevertheless had to be employed. In any case it certainly follows that the decomposition of the gutta percha which was observed is not due to the effects of time and position of the wires, but is due to the material of which the covering consists. Certainly although it appears in general that where the wire lies at a slight depth, and in light and dry ground, the phenomenon in question first takes place, yet there are always found near such altered wires others in thoroughly good condition under exactly the same conditions, on which time has left no traces; on the other hand older lines are found here and there where the wire, deeply laid and in heavy ground, is already in quite an advanced state of change, whilst close by under exactly the same conditions the wires are not to be distinguished from those newly manufactured. Hence it is only the material and not external circumstances which is the cause of the disturbing phenomenon.

From what has been said it follows that the bad results which have attended the first underground lines are only consequences of faults due to their installation, which result partly from the hurry due to the circumstances of the time, partly from the absolute want of experience regarding the properties of the material used, and insufficient care in its selection and manufacture. That the

first experiences in the use of a material up to then so little known for a perfectly new purpose and presenting so many difficulties, should not have been quite successful, may pretty certainly be expected. In such circumstances, experience must be first accumulated and paid for.

The time has now arrived when one can build further on the basis of experience actually gained, and when one is in the position to form a definite well-grounded opinion as to whether the new road will lead to the desired goal, or whether it is to be considered as having failed and is to be quite abandoned.

The following are the questions on the answering of which this decision can alone depend :

1. Does good, unadulterated and unspoilt gutta percha remain unchanged in the ground or does it undergo a slow change ?

It has already been mentioned above, that by far the greatest number of wires of the two older lines have hitherto remained entirely unchanged notwithstanding the unsatisfactory conditions in connection with them. There is not the slightest sign of any alteration having occurred to be observed amongst them.

But the experiments extend back over still another year. The test line laid on the Anhalt railway consists of non-vulcanized gutta percha. One of these wires is covered with good gutta percha thoroughly freed from water and laid at a depth of 1½ foot, the other with partly bad material and only imperfectly freed from water, and laid only ¾ foot deep in sandy soil.

The whole of the first-mentioned wire has kept in such perfect condition that it is impossible to distinguish the gutta percha from that quite newly prepared. The second shows symptoms of hardening only where bad material is employed. The resinous coating which was given to these wires, when they were laid, in addition to the gutta percha, has been partly dissolved, partly decomposed, whilst the outer surface of the gutta percha has remained quite clean and unaltered. In the wires of the newer State and railway telegraphs there has nowhere been any trace of a change in the gutta percha.

It hence follows with certainty that the gutta percha if unadulterated, and not spoiled before or during manufacture, remains unaltered when placed at a sufficient depth in the ground, and is hence quite fit for underground conductors.

2. Has the technical knowledge of wire manufacture and the knowledge of the material sufficiently advanced, that now only such wires are used as do not contain in themselves the cause of speedy decay?

The experience already gained with the newer telegraph lines answer this question in the affirmative. The lines laid in the spring of 1849 from Berlin to Hamburg and Stettin, from Breslau to Oderberg, and from Cologne to Aix-la-Chapelle, as well as the railway telegraph lines laid with underground conductors, have remained almost uninterruptedly in good order. These lines since being laid down have not once required a thorough overhaul. A few stoppages of the service were occasioned by serious injuries during laying which could not be obviated, and by railway constructions, and were quickly put an end to; others were caused by the operators being too little acquainted with the apparatus entrusted to them, and by the latter not being maintained in good condition. So far it has not been proved in any case, that on these newer lines, already in their third year of existence, any alteration in the gutta percha has occurred, or a stoppage of the working in consequence of bad manufacture of the wires. An apparent exception to this is the wire connecting the two railway stations at Breslau, which has already frequently been rendered unworkable through eccentricity of the wires; it can, however, be shown that the wires employed here belonged to a much earlier period of manufacture.

It is, however, by no means contended generally that no faults due to manufacture have occurred on these newer lines. A thorough examination of the lines will no doubt yet bring to light a number of such faults, and also here and there wires which have been spoilt by time. The occurrence of such faults could only be avoided by a very strict and thorough control of the manufacture itself, and of the material used, carried out with the assistance of all the aids of science. A thorough examination of the lines undertaken yearly by which all existing faults in the insulation are removed will, however, always be necessary with underground lines. If these examinations can be carried out, without an actual disturbance of the service, without great expense, and with complete success, as is the case here, the conductors fulfil their purpose, and the art of manufacturing

wires must be considered as sufficiently improved, although here and there defects occur. The very sensitive instruments now used in factories for testing the insulation ensure the use of only perfectly insulated wires. A very eccentric position of the conductor, toughened, burned, or adulterated gutta percha to any extent, is almost always shown up by imperfect insulation. The external signs of this bad gutta percha are clear and well known, its use can therefore be entirely prevented. It is consequently now possible to manufacture only good wire that will retain its insulation, or at least only to allow of such being used. Experience has also proved that unvulcanized gutta percha is not changed in damp ground as in sea water into a hydrate which by degrees becomes less insulating. The facts that unvulcanized gutta percha is less hard, and becomes more rapidly brittle in the open air are certainly disadvantages, but on the other hand vulcanization leads to the use of bad and damp material which is less easy of discovery. The use of unvulcanized gutta percha thoroughly freed from water is therefore more advisable, as it further reduces the danger of the use of bad wires.

3. Can underground wires be sufficiently protected against external injuries?

The depth at which the wires are laid on the newer lines referred to is 2 feet on the average. This depth appears to protect them pretty fully against injuries of all kinds which may happen to them. Yet it seems to be more advantageous to increase the depth at which the wire should be laid to 3 feet with new telegraph works for railways, etc. By using the implements employed in England for making trenches for drains, it has been made possible to excavate trenches 3 feet deep at the same price as 1½ feet formerly. According to all previous experience, this depth not only fully protects the wires against injury arising from carrying out the usual railway works, and against the gnawing of animals, but also against the entrance of atmospheric air, and removes therefore the possibility of a gradual hardening of the gutta percha. In places where the wire, owing to special circumstances, is liable to injury of any kind, or where the depth of 2½ to 3 feet cannot be reached, it can easily be protected by earthenware pipes, or by iron pipes where necessary.

Naturally what has been said is not to be understood as though

external injuries could be absolutely prevented. Experience teaches that railway works are not always executed with sufficient regard to the position of the wires. For instance, it has been the case that railway workmen have taken the trouble to destroy the wire, because they have thought it to be a troublesome root. But these are solitary cases, which are of slight importance if one keeps in view the possibility of such cases, and takes care to avoid them in future as quickly as possible. On railway telegraph and State telegraph lines, where both wires lie in the same trench, so far as I know it has never happened that such careless injuries have remained unobserved. As the position of the wires on the permanent way of the railway and in the station is always exactly known, and is indicated by stakes, it is in fact very easy always to take the necessary care when any unusually deep operations have to be carried out.

But if the answers to the different questions put must be considered as favourable to the further use of wires insulated with a covering of gutta percha alone, there are still many drawbacks in conductors so prepared. It will always be difficult to remove all faults of manufacture, and to avoid all injuries in transport and in laying the wires, as well as in subsequent excavations which reach down to the wires.

If these injuries can be removed without great difficulty, and as a rule before they can produce disturbances, which is quite possible, in the case of wires insulated as they have been up to the present, yet it must be conceded that it is very desirable to obviate the faults connected with them, and the value of underground conductors would be considerably enhanced thereby This can be effected by covering the insulated wires with lead tubing, as has been recently done. The gutta percha is entirely protected by the lead envelope against the entrance both of moisture and air. As the lead closely surrounds the wire, and any space still existing between them is filled with tallow, moisture cannot spread between the wire and the lead by capillary attraction even in cases where the lead tubing is injured in any manner.

Even assuming the case that the gutta-percha coating was not continuous, and so only insulated imperfectly, or that it consisted of bad material, yet the insulation of the wire would continue

perfect as long as the lead tubing was preserved. As regards the preservation of lead in the ground, old experiments are in existence. In pure sandy and clayey ground, which contains no vegetable ingredients, it has kept good for hundreds, indeed for thousands of years. By the action of the oxygen of the air a layer of oxide certainly forms on the lead even at a certain depth below the ground, but this decomposition only penetrates deeper when a simultaneous entrance of carbonic acid makes the formation of white lead possible. If in laying the lead tubes reasonable care is taken that no vegetable ingredients come into immediate contact with the wire, the long life of even thin lead tubes can be reckoned upon with certainty. But if through any cause the lead is anywhere injured, and the gutta percha laid bare, the insulation of the wire would only be endangered in case the same influences which gradually injured the lead acted in the same way on the gutta percha, which, considering the absolute difference of the materials, can only occur in a few cases or not at all. The lead covering also secures the insulating gutta-percha coating from injury during transport and in laying; it further makes the discovery of existing injuries more easily traceable, and entirely protects the gutta percha against the action of the air when not laid deeply. The gutta percha, even when of bad quality, must remain perfect in the lead pipe, which preserves it from all external influences. The volatile oil contained in burnt gutta dercha, through the volatilization of which the mass gets hard and brittle even in the ground, cannot get away through the closely surrounding lead covering, and remains therefore in the gutta percha and keeps it flexible.

Against the use of lead there is, besides the increase of cost, a phenomenon of quite a different character—viz., the increase of the charging phenomena peculiar to underground lines, which, however, is not so considerable as was to be expected according to the experiments already made on the telegraph line connecting the fire and police stations in the town of Berlin, which is about seven miles long, and in which wires covered with lead were used throughout, and it can be made harmless by the choice and arrangement of the telegraph apparatus. The increase of cost due to encasing the insulated wires in lead is not so considerable as appears at first sight. As the insulating covering is protected

against all external influences, it can without danger be made considerably lighter. The saving in gutta percha then makes up for the greatest part of the cost of the lead covering ; besides, the higher amount of insulation to be got with lead tubes allows of the use of thinner wires for long lines.

From what has been said, it will be allowed by any unprejudiced critic that the first underground lines laid in Prussia were laid under such unfavourable circumstances, that the experience gained from them can only be used with great caution in reviewing the value of the system of underground lines. The bad manufacture of the wires used for the purpose, the partial use of bad sorts of gutta percha, the slight depth at which the wires were laid, the laying of the wires in a great hurry at an unfavourable season and with inexperienced people, have exposed them to too many sources of disturbing influence and rapid decay. A more exact consideration of the results of the older lines, and the experience gained with the conductors more lately laid, are, on the contrary, altogether favourable to underground lines if due account be taken of the faults at present avoidable, which were made in the latter, for the most part from want of experience. With all the newly-laid underground conductors, and with those that were laid immediately after the two first mentioned, no alteration in the gutta percha has been observed, although the depth of laying was still too small. Faults in construction, rendering an overhauling of the conductor necessary, have but seldom occurred. Very few injuries have occurred during the laying of the wires, and later external injuries have but seldom taken place. If the inspection of the underground State telegraph lines had been already properly organized, if there had been a regular and thorough yearly revision, and a constant exact control of the insulation of the lines, if not all, but a great number of the telegraph employés had been made intimate with the simple manipulations for detecting and repairing bad injuries, the disturbances or interruptions which have only seldom occurred in the service of these lines would have been removed in a very short time, and the cost of maintenance of these lines would have been very small. As it must also be admitted that overhead lines have many undoubted superiorities over underground ones, and always will have, yet these advantages and the actual dis-

advantages of underground lines known to exist must not lead to a partial judgment. The balance between the advantages and disadvantages of the two systems of lines must decide. This may be set out in some such way as follows:—

The advantages of overhead over underground lines consist mainly in that the former are more easily inspected and repaired, since they are always visible; that up to a certain limit an increase of the wires, when occasion requires, can be effected at less cost; and that the cost of erection is in general less than with underground lines. There are, however, a great many disadvantages opposed to these advantages; overhead lines are much more liable than underground to malicious and accidental destruction. Although the damages are more easily and quickly repaired, and the stoppages of the service therefore shorter, they occur on that account all the more frequently, and it is only by the use of very solidly constructed overhead lines that the same safety of service can be attained as with the hitherto existing underground ones. If copper wire and light poles are used for overhead lines, as was formerly most frequently the case in Germany, very perfect insulation can certainly be obtained with them, and the erection is certainly considerably cheaper than with underground lines. The wire, however, as experience has shown, is very apt to be stolen; it stretches by degrees, and hence easily comes into contact with other wires suspended from the same posts; it becomes brittle after six or eight years' use, and must then be renewed; the posts decay and are then easily blown down by storms, and thus endanger the safety of the railway service. More satisfactory results are obtained with the use of iron wire for overhead lines, when heavily and well galvanized. Thin iron wire is easily destroyed by rust, and has too low a conductivity for long lines. The galvanizing of iron wires is only of use in cases where the zinc is actually melted together with the iron when the two metals are in contact, and in consequence does not crack off or become split when the wire is bent. The operation by which this is effected appears hitherto, notwithstanding the publicity of the description of the patented process, to have been the secret of a few English factories, which supply their manufactures at a very high price. Ungalvanized or badly galvanized wires, even when thick, rust, especially at their points of suspen-

sion ; the wires break very easily on this account at these points. Thick iron wires must, of course, be tightly stretched, so as not to come into contact with others, and therefore necessitate the use of strong posts and special stretching arrangements, in which way the erection is rendered much more expensive. As is learnt especially from experience in England, where, as a rule, a larger number of wires is suspended on the same posts, a constant very careful examination of the wires must be carried out, they must be frequently tightened up, and on the arrival of frost be slackened again, as otherwise the wires touch one another or get broken. This, as a rule, renders all the wires for the moment unavailable, as the ends of those that are broken come into contact with the others. Even iron wires become brittle at the end of eight or ten years, and many English lines have had to be renewed on this account, whilst even with the mild winter of that country, and notwithstanding every precaution, the wires have been frequently fractured. It has not hitherto been possible to insulate the stretching arrangements completely from one another and from the ground. With a fall of snow or rain, and even in very misty weather, very frequent disturbances take place in England, and hence one is only able in such cases to make use of one or at best a pair of all the existing wires.

Owing to the close connection which exists between the English telegraph company and the railways, the necessary inspection of the wire is carried out by the railway employés at no great cost to the company. It is at least questionable whether this would be always everywhere the case with the Prussian State telegraphs in their own and foreign lands.

All the faults of overhead lines that have been described would certainly, however, not decide the question in favour of underground lines if electrical disturbances did not always make the use of long overhead lines unsafe. The better overhead lines are insulated, the more, therefore, the source of disturbances due to bad insulation has been prevented, the more frequent and powerful are the electrical disturbances. In this case, from experience on short lines, conclusions cannot be drawn for long lines. The leakages which frequently occur to a large extent with underground lines, in consequence of imperfect insulation, have always a constant character, and can hence be rendered harmless to a

great extent by a proper arrangement of the instruments. The currents produced in overhead lines by atmospheric electricity are, on the contrary, always variable, and hence make the use of the instrument uncertain even if they are very weak. On the long overhead lines in America the relay of the Morse telegraph can but seldom be used, for only by means of colossal batteries can the constant bother of atmospheric electricity be rendered harmless within certain limits. Further, there is also the danger which cannot be overcome with overhead lines, that flashes of lightning may destroy the wires and posts over long stretches, and endanger the employés and instruments. By means of suitable lightning conductors, the station offices and the apparatus contained in them may be protected to a certain extent, but not the signal cabins of the railways, in which gongs are placed, which are set in action by means of the electric current. It has often happened on the Prussian railways with overhead lines, that railway servants have been deafened and even struck dead by lightning. The signalmen, therefore, leave their cabins when thunderstorms come, and prefer to expose themselves to the bad weather in order to escape from threatened danger to life.

On underground lines only actual thunderstorms and flashes of lightning exert a slightly disturbing effect on the service of the apparatus. Even with the at present imperfect underground installations a sudden total disturbance of the line occurred very seldom, and could be put right in a very short time by means of a properly organized inspection. The causes of disturbances which have arisen have consisted for the most part in injuries that have happened from some causes or other to the external covering of the wires, being followed by a gradual deterioration of the insulation and finally by the complete corrosion of the copper wires. It is, however, again a question of good management, not to allow the insulation to be spoilt, but to remedy defects as they occur before they can exert a harmful effect on the safety of the service.

Owing to a great drawback which occurred with the Prussian telegraph installations, viz., the provision of a single wire for the whole of the communications, this was certainly rendered more difficult. The overhauling of single underground conductors could certainly be carried out without absolutely disturbing the

service of the apparatus, yet every interruption which takes place is followed by a cessation of the whole of the correspondence, whilst in other countries one line can be used until the damaged second one be repaired. The overhauling of underground conductors is in itself immensely more difficult when only one wire exists, even setting aside its simultaneous disturbing use. It is difficult with one wire to determine an existing injury by means of measurements of current and calculations, and especially because the measurements must be made simultaneously at both ends of the wire. If, however, two or more wires exist, the position of one or several injuries can generally be determined with the greatest accuracy by a simple measurement of resistance made in the telegraph office, whereby the repairs are naturally extraordinarily simplified.

The cost of laying underground lines will always be higher than that of overhead; whether, on the other hand, the cost of maintenance of well-laid underground lines with carefully organized inspection is greater is at least still questionable. But, even assuming that it were greater, neither the interest on capital account nor the cost of maintenance of the conductors form the factors determining the profitableness of telegraph lines. The charges of the general management and the cost of the skilled employés are, specially in the Prussian State telegraph lines, incomparably the most considerable. The cause of this is partly that, for reasons which do not belong to the discussion, a number of stations, entirely unimportant for telegraphic correspondence, had to be included on the single existing wire, in which way the service was rendered considerably more heavy, and an exceedingly large number of employés were necessary as compared with foreign telegraph lines; further, that the conditions of the country rendered it necessary that only time-expired military men could be employed as telegraph servants, whilst in other countries young people, often, indeed, boys, perform the service and are almost overworked by their occupation. In Prussia one has consequently chosen, as regards the service performed, a more costly system, but one giving a greater guarantee of safety. The greater expense thus incurred can only be outweighed by greater certainty of the service of the telegraph lines, if causes of regular disturbance exist not lying outside the reach of the employés. If the conviction has thus

been gained, that with good underground lines, laid by applying the experience and progress hitherto attained, a greater security may be attained as regards the service of the line, the greater cost of laying cannot be brought as sufficient reason for the rejection of a system producing better results. In every respect electric telegraphy is in the infancy of its development. It can only rise above this condition and attain the position due to it as a mighty lever of State mechanism and of public intercourse if its fitness for service and the certainty of its communications can always be reckoned on, and safe and quick satisfaction is given to every claim, with moderate charges. Up to the present time it has never reached this height, and it can only do it with the help of a comprehensive system of good underground conductors. Already with the present development of telegraphy in England, where the railway, as a rule, has only two to four wires for its use, and the telegraph company a pair for its correspondence to the most important parts of the country, and a pair for through transmission to the terminal stations, there is such a complication of wires, especially at those points where two or more lines unite or cross for a short distance, and mutual disturbances occur so easily, that it may be asserted with certainty, that such a considerable increase of the wires as would be necessary with a general use of the telegraph is not possible without occasioning great trouble and uncertainty. The same argument, which is in favour of a system of overhead lines for electric telegraphy, still in its infancy, would, on further extension, certainly be opposed to it. With underground wires, indeed, it is necessary, in order to avoid the addition of a line which would soon be required to do the work on a larger scale, and to lay at least one wire more than at the moment appears to be necessary. Enough land must also be taken along the road which the wires traverse in view of the subsequent work. It is, besides, not so difficult and costly as appears at first sight to take up the wires already laid and to put them back at the same time as the additional ones after an exact test has been applied to them on the spot, and any earlier injuries or any arising from the work are put right. The disturbance of the service by this work may easily be prevented without any considerable cost by the use of a temporary overhead conductor,

which is used as long as the work lasts and may be removed when it is completed.

The object of this paper has been to show that the unfavourable results which have been experienced with the first laid underground wires in Prussia are not a consequence of the system employed, but are mostly due to faults in the laying and in the administration afterwards owing to want of experience and unfavourable circumstances.

These faults are mostly avoided in the later layings, and may be completely removed by a right use of the experience gained and the progress of technical science. But it is to be regretted that through these unsatisfactory results a very general and unfounded prejudice has arisen against the system of underground conductors. Their real value can only be decided by an exact comparative analysis of previous results carried out by scientific men acquainted with the subject. It would, therefore, now be highly important and practically advantageous if the Government would again act as it has previously done, and would obtain the opinion of a scientific commission on the results already obtained and the measures to be made use of, as well as on those organic arrangements of administration which are necessary for the regular maintenance of the service of the lines and of the whole establishment.

APPLICATION FOR A PATENT FOR AN IMPROVEMENT IN THE CONSTRUCTION OF RELAYS.*

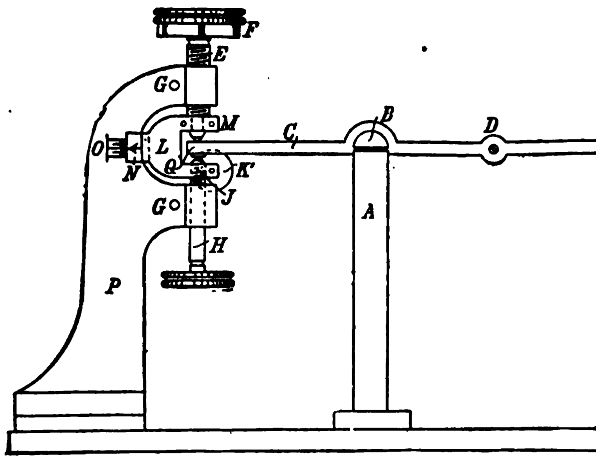
In the use of relays for telegraphic purposes it has become apparent that, when speaking over greater distances, the armature must be further removed from the magnet than when speaking over shorter distances, but the play of the contact must be smaller. In order to effect the necessary alteration of the position of the armature easily and certainly in the case of telegraphs which are alternately used to signal to near and distant stations, which was formerly a lengthy and uncertain business, the following arrangements have been made :—

* 7th February, 1852.

In Fig. 38, A is the magnet of the relay, C a lever movable about D, which carries the armature at B, and makes contact at Q, placed in the recess of the piece L. The piece L is provided with two similar little plates N ; of these only the one, which carries the index, is seen in the drawing. These little plates secure the piece L against lateral motion.

L is guided vertically by means of the cylindrical neck of the

Fig. 38.



screw H, which has a fine thread at J, so as to set the play of the contact once for all, and is fixed by means of the screw K.

The screw E has a neck above the insulating stop, which has its bearing in the piece L, and by turning the screw E the piece L rises or sinks, and so determines the distance of the armature.

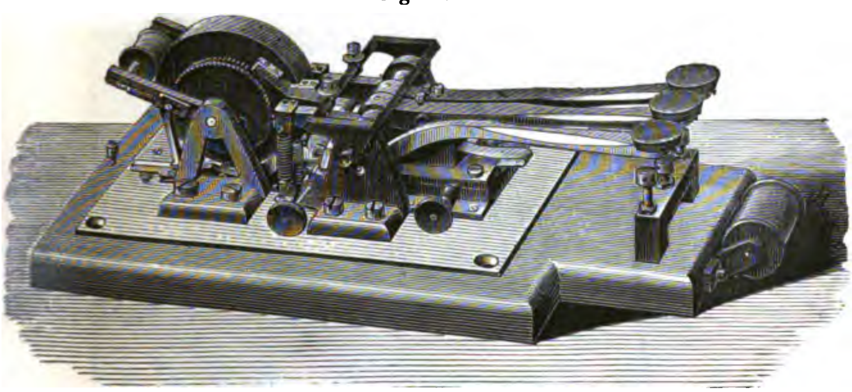
The distance once fixed can be found again with great precision by reading the scale O, which corresponds to whole rotations of the screw, and by the divided head F connected with the screw E, which is divided into 5ths of a revolution. The position of the piece L is further secured by the clamping screws G G.

THE AUTOMATIC TELEGRAPH SYSTEM FOR THE RUSSIAN STATE TELEGRAPHS.*

The system of apparatus shown in Figs. 39–42 was constructed for automatic rapid telegraphy for the State telegraph lines built by the firm of Siemens and Halske in Russia in the years 1853–55. The first line provided with such apparatus was that from Warsaw to St. Petersburg, with an automatic relay station at Dünaburg.

Fig. 39 shows the three-key type perforator described in detail in the following paper at page 106, which serves to punch

Fig. 39.



the Morse signals on a paper strip. The message so prepared was telegraphed by the quick sending instrument represented in Fig. 40, in which the perforated paper strip was drawn between a metal roller and a metal pencil pressing elastically against it.

As a receiving apparatus, the rapid printer shown in Fig. 41 was used, a point writer equipped with a rotating magnet core peculiar to Siemens and Halske's oldest Morse apparatus, the so-called Camel form.

The two electro-magnets m and m^1 are placed on their sides, the core of the first is revolvable within its fixed bobbin about the axis C, and prolonged into peculiarly-shaped pole pieces $p\ p$, which

* 1853.

Fig. 40.

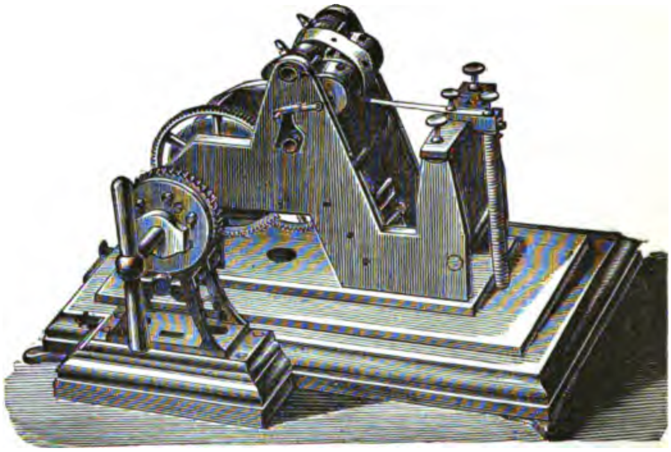
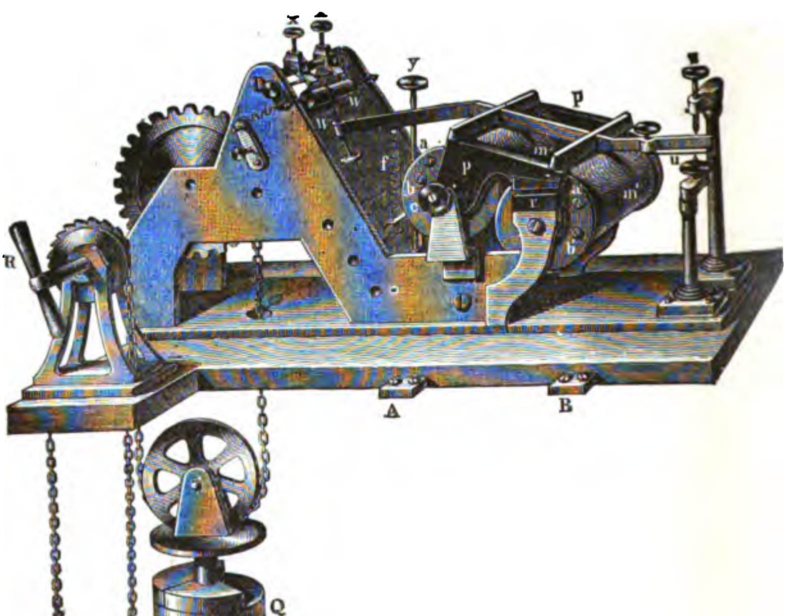
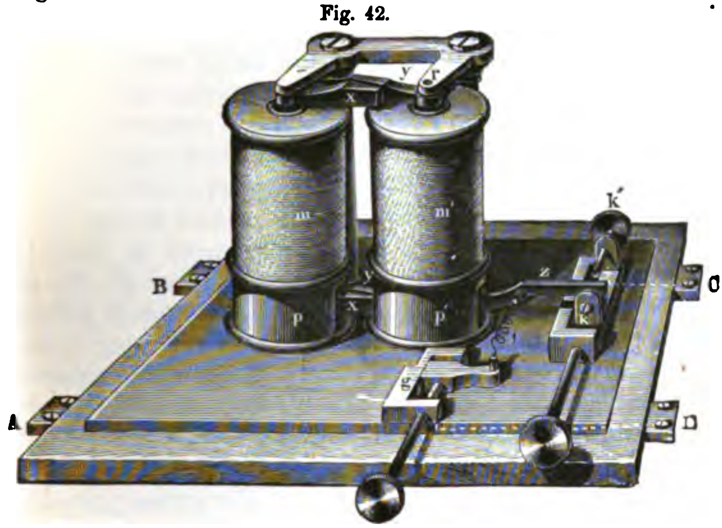


Fig. 41.



are close opposite to the fixed poles *r r* of the second electro-magnet *m*.

Fig. 42.



The relay shown in Fig. 42, also provided with a revolving magnet core, is essentially similar to that described in the following paper, pp. 105, 106.

ENGLISH PATENT SPECIFICATION WITH REGARD TO ELECTRO-MAGNETIC DUPLEX SPEAKING, TRANSLATORS WITH REVOLVABLE MAGNET CORES, AND THREE-KEY PERFORATOR FOR AUTOMATIC TELEGRAPHY.*

1. *Certain arrangements whereby signals may be simultaneously transmitted in both directions by means of a single line wire.*†

Figure 43 represents one of these arrangements. It consists of

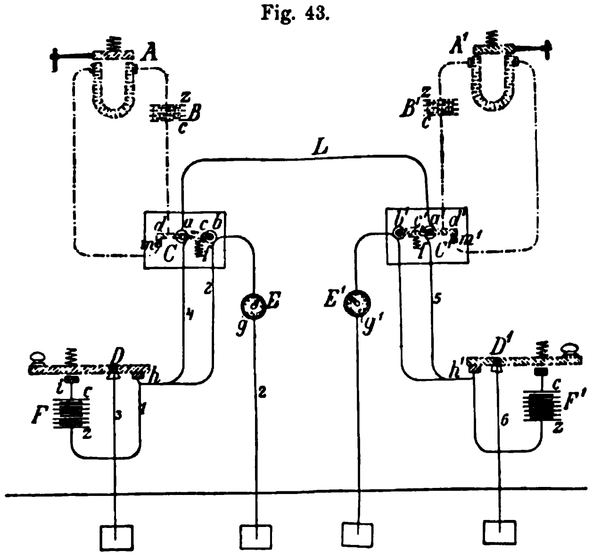
* Patent, 1854, No. 2366, pp. 6—11.

† The method adopted by Werner Siemens for duplex working on the electro-magnetic system, was simultaneously worked out by Mr. C. Frischen of Hanover; both inventors therefore combined their interests later on.

two telegraphic instruments A, A^1, placed at the opposite stations, which instruments are by preference of the kind called "Morse instruments." These instruments are worked by local batteries B, B^1, and the local circuits are shown dotted on the drawing. C, C^1, are transmitting instruments, consisting each of two electro-magnets *a*, *b*, and soft iron levers *c*, *d*, that are fixed upon the electro-magnets within the coils. The electro-magnet *b* with its arm *c* is fixed, whereas the electro-magnet *a* with its double lever *d* is free to rotate, being held back against its stop by its spring *f*. This transmitting apparatus is shown in detail by Figure 45, and will be more fully described later. D, D^1, are keys, or contact levers, such as are commonly used in working Morse telegraphs. E, E^1, are resistance coils, consisting of considerable lengths of thin German silver wire, that offers a resistance equal to that of the line wire. This resistance can be regulated or adjusted by turning the small hands g, g^1. F, F^1, are galvanic batteries for working the telegraphs. In depressing the key D, the circuit of the battery F is completed. The current proceeding from the zinc pole of this battery passes through the wire 1 into the piece of metal *h*, which at this time is not in contact with the lever D. The current proceeds from *h* in two directions; firstly, through the wire 2, the coils of the electro-magnet *b*, the resistance coils E, into the earth; from the earth through the wire 3 and the key D into the contact piece *i*, and hence to the copper pole of the battery F; secondly, a current proceeds from *h* through the wire 4, and the coils of the electro-magnet *a*, into the line wire L. At the opposite station the current passes through the coils of the electro-magnet a^1 and the wire 5 to the piece h^1, hence through the key D^1 and the wire 6 into the earth; from the earth it passes through the wire 3, and the key D also, to the copper pole of the battery F. It will be observed that both the electro-magnets *a* and *b* of the instrument C will be equally excited, and the levers *c* and *d*, being made similar magnetic poles, will repel each other, and consequently no motion will ensue. At the other station the current produces its effect only on the electro-magnet a^1, and its moveable arm d^1 consequently draws itself towards the fixed arm of soft iron c^1, and thereby establishes contact between the extreme ends of the lever d^1 and the contact piece m^1; the circuit of the local

battery B¹ is thereby completed, and the armature of the instrument A¹ will be attracted so long as the key D at the opposite station remains depressed, thereby producing a mark or sign upon a strip of paper. It will be readily understood that in depressing the key D¹ a motion of the instrument A will be produced, in precisely the same manner as before described with regard to the key D and the instrument A¹. Whenever both keys D and D¹ are depressed at the same time, both batteries F and F¹ are

Fig. 43.



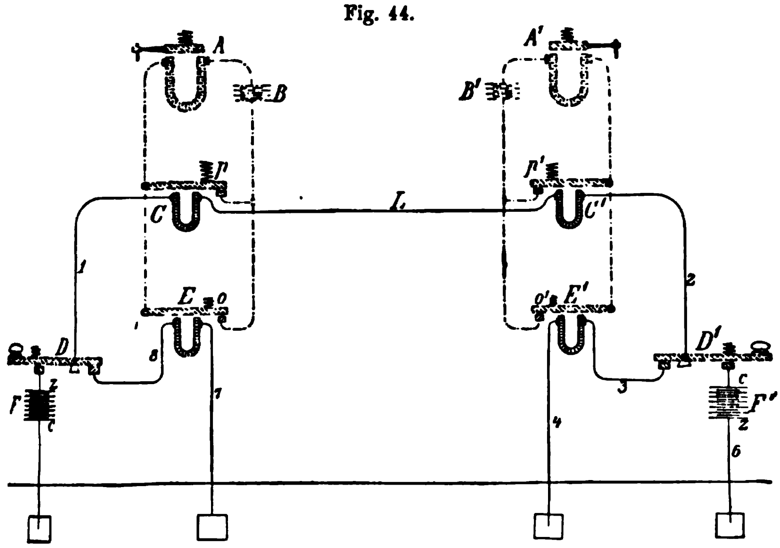
brought into the circuit of the line wire with their similar poles opposed to each other. The power of the two batteries being nearly alike, there will be no appreciable current passing the line wire, and consequently the electro-magnets a and a^1 will not be affected. The local circuits, passing from each battery through the electro-magnets b and b^1, and the resistance coils E and E¹, respectively, will excite magnetism in the fixed arms c, c^1, which in their turn will attract the levers of soft iron d, d^1, and thereby establish the local circuits of both instruments. The instant that one of the keys (the key D, for example) is released, the battery F will be thrown out of the circuit, and the magnetism

of the electro-magnet B will cease. On the other hand, the current from the battery F^1 will pass through the line wire, and excite the electro-magnet a, which in its turn will be excited at the instant the excitement of the electro-magnet b ceases; the arms c and d will remain in proximity, and the local circuit of the telegraph instrument will continue. At the opposite station the battery F^1 will continue to excite the electro-magnet b^1 by its local circuit, and commence to excite the electro-magnet a^1 by the line wire circuit. The two arms c^1 and d^1 will repel each other (being made similar poles of two electro-magnets), and the local circuit of the battery B^1 will be broken. It is true that the line wire current arriving at the point h will not entirely proceed through the lever D and the wire 3 to the earth, but a small portion of it will pass through the coils of the electro-magnet b and the resistance coils E into the earth; the arm c will in consequence retain a proportion of magnetism, which, however, will be so small, as compared to the magnetism of the arm d, that it may be entirely disregarded. It is important that the resistance coils should be regulated from time to time to that encountered in the line wire. To effect the adjustment a galvanometer is provided, the needle of which is placed in a coil of two wires; the one forming part of the local circuit, and the other of the line wire circuit. If, on depressing the working key, the needle is deflected, a preponderance of one current over the other is proved, and the hand on the resistance coils must be moved till the depressing of the working key produces no visible effect on the galvanometer. The needle of this galvanometer will always be deflected when the key of the instrument of the opposite station is depressed, and may be used indeed as a needle telegraph instrument. The arrangement just described will also produce the desired effect when the poles of the battery are reversed. On depressing both keys simultaneously, the line wire current will in that case attain twice the intensity of the current passing through the resistance coils or local circuits, and the magnetism of the electro-magnets a and a^1 will cause the levers d and d^1 to be attracted, notwithstanding the similar magnetism in the arms c and c^1.

Figure 44 represents another arrangement for effecting simultaneous communications in both directions through the same

line wire. A and A^1 are telegraph instruments, worked by the batteries B and B^1 respectively whenever the local circuit is completed. C and E on the one side, and C^1 and E^1 on the other side, are transmitting apparatus for closing the local circuits. The armatures of the instruments E and E^1 are retained against their stops by springs o, o^1, whereas the armatures of the instruments C and C^1 are retained by springs of double the power p and p^1. If the working key D is depressed, a current will

Fig. 44.



proceed from the zinc end of the battery through the wire 1, the coils of the instrument C, and the line wire, through the coils of the instrument C^1 at the opposite station, the wires 2 and 3 through the coils of the instrument E^1, and the wire 4 into the earth, from whence it will proceed to the copper pole of battery F through the wire 5. The current of the battery will excite an equal amount of magnetism in the electro-magnets of the instruments C, C^1, and E^1, which amount will not be sufficient to overcome the retaining force of the larger springs p and p^1, but is sufficient to overbalance the weaker spring o^1, and in attracting the armature of the instrument E^1, to establish the current of the

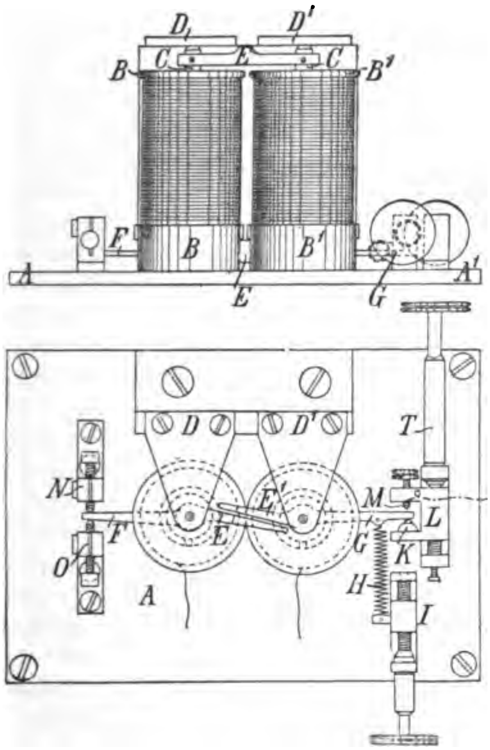
local battery B^1. The telegraphic instrument A^1 will produce a signal, whereas the instrument A is unaffected. If, on the contrary, the key D^1 is depressed, the current will pass from the zinc pole of the battery F^1 into the earth through the wire 6, and thence through the wire 7 at the opposite station, through the coils of the instrument E, the wires 8 and 1, the coils of the instrument C, the line wire L, the coils of the instrument C^1, the wire 2 and key D^1, to the copper pole of the battery F^1. The magnetism produced in the coils of the instruments E, C, C^1, cause the armature of the former only to move (being retained by the weak spring *o*), and thereby to establish the circuit of the local battery B, and produce a movement of the telegraph instrument A. If the working key D should be depressed at the same time with D^1, then the two batteries F and F^1 will both be brought into the line wire circuit. Proceeding from the zinc pole of the battery F, the current will traverse the wire 1, the instrument C, the line wire L, the instrument C^1, the wire 2, the key D^1, the battery F^1, and the earth, and will reach the copper pole of the battery F through the wire 5. The accumulated force of both batteries suffices to overcome the retaining force of the stronger springs p and p^1. The armatures of the instruments C and C will both be attracted, and establish the circuits of the local batteries B and B^1. The simultaneous movement of both telegraphic instruments is thereby insured.

Translating Apparatus (*Instrument*).—Figure 45 shows an elevation and a plan of my improved translating apparatus. Upon the base plate A are placed two hollow cylinders of wood, BB^1, upon which the wires are coiled in the usual manner. The cavities in the cylinders B B^1, contain rods or tubes of soft iron, which nearly fill the same, but are free to rotate upon steel centres. The rod or tube of iron in the cylinder B carries two arms of soft iron, E E, at top and bottom. The rod or tube in cylinder B^1 carries two similar arms, E^1 E^1. A brass arm, F, projects from the lower arm E, and terminates between two set screws, N and O, by means of which the position of the arms E and E can be adjusted and fixed. A similar brass arm, G, projects from the lower arm E^1, and terminates between an insulated abutment, K, and a metallic contact screw, M.

The lever G is retained against its insulated abutment, K, by

a spiral spring, H, the tensile force of which can be regulated by the adjusting screw I. The abutments, K, M, are supported by a metallic piece, L, which can be moved bodily by means of an adjusting screw, T, in order to regulate at any time the distance

Fig. 45.



between the arms E and E^1. The length of movement of the arm G, and consequently of the arms E^1 and E^1, is regulated independently, by means of the set screw M. If a galvanic current traverses the coils of the electro-magnets, the arms E and E and E^1 and E^1, will attract each other, and the arm G will be moved against the metallic point M, to establish the local circuit of the telegraphic instrument.

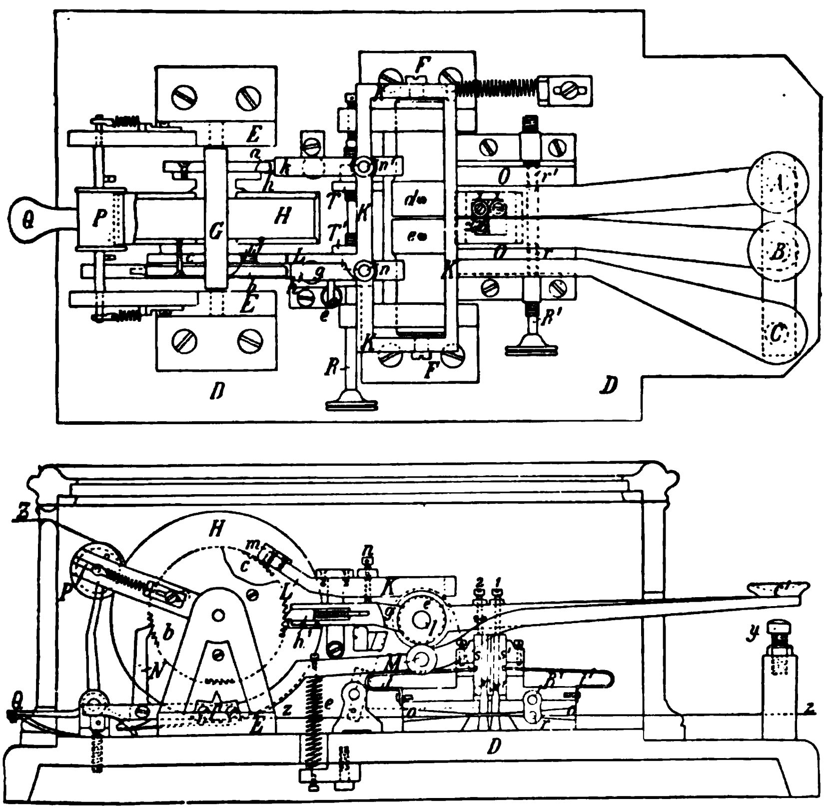
Instruments constructed in a similar manner and with similar adjusting apparatus may be employed with advantage for the telegraph instruments A and A^1, in Figures 43 and 44.

3. *Three-key Perforator.*—Perforated strips of paper have been heretofore employed for communicating signals in the telegraph known as Bain's chemical telegraph, and in this case the various signals were formed by combinations of dots and lines, produced by corresponding round holes and elongated holes in the strip of paper. In applying a strip of paper with both round or short holes and elongated holes to Morse's telegraph, in which the signals are formed by dots and lines marked by a pen or pencil connected to the armature of an electro-magnet, it is found that the rapidity of the action is limited from the following cause:—If the velocity of the paper be such that there is just sufficient time for the action of the electro-magnet during the passage of one of the short holes past the finger or scriber, then it will be found, that during the passage of one of the elongated holes, the residuary magnetism is such as to retard the return of the armature, and thus interfere with the rapidity of working. This defect is obviated by making all the perforations of the same size or length, and producing the signals by their greater or less proximity to each other; thus, two round holes very close together serve instead of one elongated hole.

Figure 46 is a plan and a section of the mechanism I employ for perforating the strips of paper. A, B, C, are three keys, that are held up by springs, and can be depressed till they strike the abutment screws *y*. The keys A and B turn upon a centre, I, with their bosses, *d* and *e*. The boss *e* is armed with a lever, carrying at the end an elastic catch, h^1, that inserts itself between the teeth of the wheel *b*. The boss *d* of the key A carries a similar lever, *k*, that inserts itself with its elastic catch *h* into the teeth of a smaller wheel, *a*. The wheels *a* and *b*, together with a check wheel *c*, and a hollow drum H, are fixed upon a shaft G, that has its bearings in brackets, E, E. In depressing the key A, the catch *h* of the lever *k* is lifted over one tooth of the wheel *a*, and in releasing the key, the wheel *a*, and with it the drum H, is turned. To check the motion of the drum, the catch wheel *c* and the catch lever L are provided. This lever extends from a moveable frame, K, that is lifted in depressing one of the keys by

means of the set screws *n* or *n*¹, in order to release the wheels *c*, and to arrest the same when its motion, imparted by the levers *k* or *g*, is completed. The strip of paper *z* enters the machine below the keys A and B; it passes through a slot of a metallic

Fig. 46.



piece O, and over a portion of the drum H, which it leaves after passing the pressing roller P, after which it leaves the machine. The roller P is pressed against the drum H by means of springs, but can be drawn back by the lever Q for the purpose of entering the strip of paper. The paper advances with the drum H after every depression of the keys A or B; it also advances in

depressing the key C, which rotates upon the spindle M, and carries at its end a catch, N, forcing the wheel *b* round. The motion of the wheel *b* is stopped by the entry of the check *p* between the teeth of the wheel. In depressing the key A, two sliding pieces *s* and s^1 are pressed downwards by means of the set screws 1, 1, and the two steel punches x, x^1, are forced through the strip of paper *z*. On relieving the key, the springs t, t^1, lift the slides, s, s^1, and the strip of paper containing two consecutive holes is moved forward in the manner described. If the key B is pressed down, only one hole will be punched through the paper by the punch x, being depressed by means of the set screw 2 of the key B; on releasing this key the advancement of the paper is less than before, because the wheel *b* is larger than the wheel *a*. At the termination of every word the key C is depressed, whereby the paper is advanced without being perforated. It is important that the line of perforations should follow the centre of the strip of paper, but as the breadth of the strips may vary, the following means are adopted of guiding the same :—The spindle R passes through sliding pieces T and T^1 with right and left handed screw threads, whereby the two sliding pieces are simultaneously moved towards or from each other in turning the spindle R. The sliding pieces reach down to the base plate D, and are so adjusted that they touch the strip of paper on both sides. A similar adjustable guide is provided in the shape of the spindle R^1 and the sliding pins r, r^1.

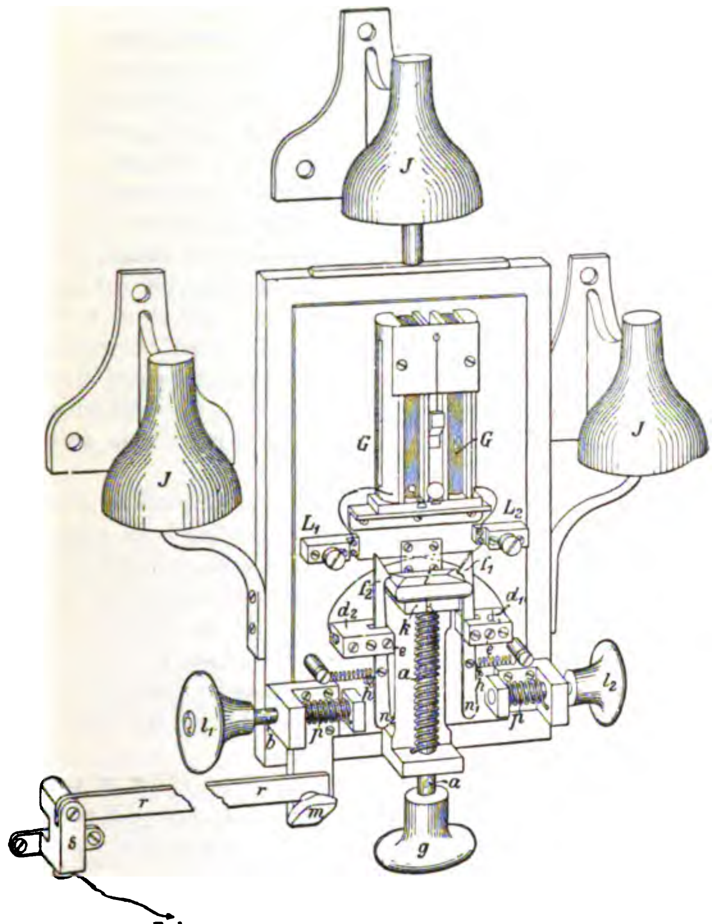
THE CONTROL GALVANOSCOPE OF SIEMENS AND HALSKE, 1855 AND 1865.*

Preface.—The first of the two control galvanoscopes described in the following—the so-called Tartar galvanoscope—was constructed in 1855 for the imperial Russian telegraph lines, and rendered it possible for the firm of Siemens and Halske always to carry out their obligation, to repair each damage to the lines within six hours. The second instrument, made for the Russo-

* Zeitschr. des deutsch-österr. Telegraphen Vereins, vol. xv. p. 69.

American line in the year 1865, is a modification of the older one, and is on that account described in this place in connection with it.

Fig. 47.



The control galvanoscope consists essentially of the galvanoscope G (Fig. 47) and the three spring knobs l_1 l_2 and g, which are mounted on a common base plate but insulated from one another.

To the guide rod of the knob g, which, when at rest, is pressed downwards by a spiral spring, there is attached a metal piece i, against which the metal levers f and f_1 are pressed by spiral springs. The knobs l_1 and l_2 are in metallic connection with one another, and also with the terminal s, which leads to earth, when the lever r is in place, and the screw m is screwed home.

By means of the terminals L_1 and L_2 the apparatus is permanently inserted in the circuit, and the current coming from L_1, for instance, passes through d_1, e, f_1, i, f_2, e, d_2 to L_2, without the resistance of the conductor being materially increased. If the knob g, and by its means the metal piece i is pressed up, i is removed from contact with f_1 and f_2, and these levers move over against the pins h, h. Then the galvanoscope is directly inserted in the line. If now the knob l^1 is pressed, the guide rod b comes into contact with n_2, whilst it could not reach it at n_2 in the position of rest of the lever f_2, L_2 is then directly connected to earth through d_2, e, n_2, b, p_1, whilst a current coming from L_1 passes to earth through the galvanoscope G, in the same direction. By pressing the knob b_2 the galvanoscope is inserted in a similar way in line 2.

The linesman should, therefore, be able at all times to ascertain by means of this instrument, whether the line is in order, and whether it works or not, and, in the last case, on which side the break is to be sought. As a rule, determined times of the day are prescribed beforehand for this purpose. If the linesman wishes to see whether the line works, he pushes the knob g. In this way he inserts his galvanometer, since he breaks its short circuit. If the line is working, he sees the galvanometer needle deflected in irregular oscillations to the right and left.

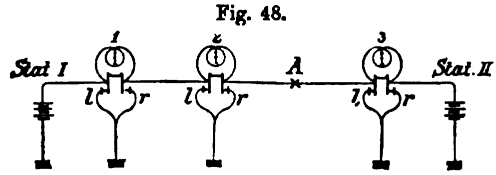
He then lets go the knob without touching either of the two side knobs. If the needle, on the contrary, is quite still there are two possible cases. Either no working is going on at the moment or there is a break in the line. In order to find out which is the case, the attendant, according to instructions given him in advance, presses at frequent short intervals on the centre knob. If no movement occurs, or if the needle is permanently deflected to one side, it is to be assumed that there is a break in the line. In this case the stations are directed to insert their signalling batteries permanently between the line and the earth. The

linesman then presses, simultaneously with the centre knob *g*, first the one, and after he has let go this one, the other side knob. He thus brings the two ends of the galvanometer wire successively into connection with earth.

Were the line nowhere broken, and if besides both stations I and II (Fig. 48) had their signalling batteries continuously in circuit, the galvanometer would be deflected by the battery of station II, when the knob of conductor I was depressed, and on the other hand by the battery of station I, when the knob of line II was depressed.

But if the line between the control stations 2 and 3, for instance, is broken, the contact station 2, and all lying between it and station I, receive only the current of battery I, when the left knob is pressed. All the linesmen, therefore know whether the fault

Fig. 48.



lies on their right or left side. As the control stations, which do not lie in the section where the fracture is, receive all the signals of those lying near them, they learn thereby that the lines on both sides of them are in order.

Those linesmen, on the other hand, who receive no through signals, know the direction in which they must examine their line, in order to find the fault.

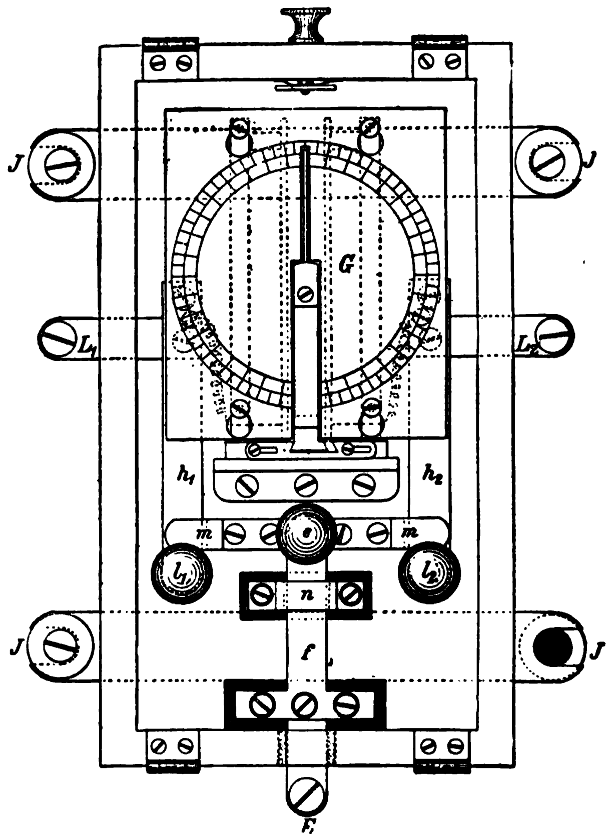
Only during the tests must the lever *r* be inserted in the clamp screw *m*; the connection must, however, be opened at other times, so that leakage to earth may be avoided as much as possible.

For the same reason also the apparatus must not be fixed directly to the wall, but insulated from the wall by means of the three insulators J, J, J.

Another more recent construction of the control galvanoscope, which was got out for the Russo-American line in the year 1865, is shown in Figs. 49 and 50, in three-eighths of its natural size. Fig. 49 is a front view, with the cover removed; Fig. 50 a vertical

section, through the axis of the needle of the galvanoscope; Fig. 51, finally, is a diagram of the connections. As may be seen, in this apparatus the contact places as well as the keys and the galvanoscope—(which is, for the rest, of exactly the same con-

Fig. 49.



struction as the table galvanoscope of Siemens and Halske's manufacture)—are contained in a lock-up case.

This must first be opened with the proper key *d*, and the lower half of the cover must be let down in order to get at the knobs. The upper half provided with a glass disc in front of the dial

of the instrument can be raised after the lock is opened, if an adjustment of the galvanoscope should be necessary. The whole case is fixed to the wall in a vertical position by means of four insulated screws J, J, J, J.

Of the three terminal screws projecting from the case, L_1 and

Fig. 50.

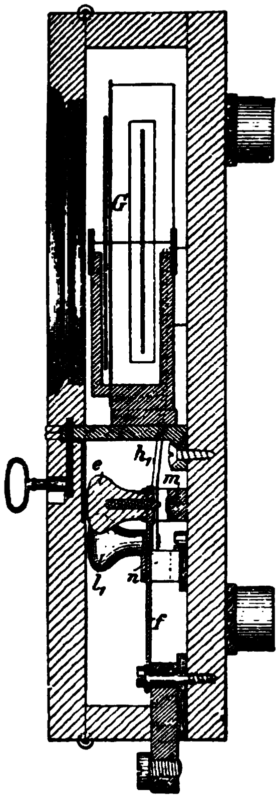
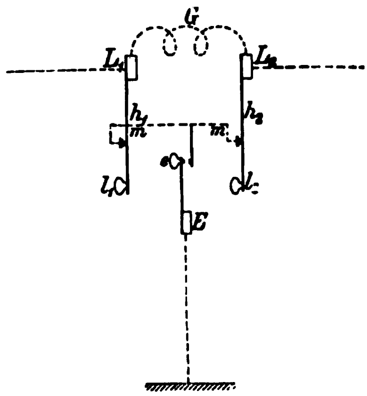


Fig. 51.



L_2 serve for the two line wires, E for the earth wire. To the bars which carry the terminal screws L_1 and L_2, the two ends of the galvanoscope windings are connected on the one side; on the other are fixed the metal springs h_1 and h_2, provided with the knobs l_1 and l_2, which spring outwards, and lie firmly against the outward bent ends of one, and the same metal piece *m m* placed over them. The metal blade *f* fixed to the earth bar also springs outwards, and is caught by the insulated stirrup *n*; it is insulated in this position from the cross-bar *m* below it, but can be brought into contact with it by pressing down its knob *e*.

When none of the three knobs is pressed down, the springs h_1, h_2 resting on the cross-piece *m m*, form with it a direct connection between both conductors, the galvanoscope is cut out. If the latter

is to be inserted between the conductors, the short circuit through *m* must be broken by pressing down one or both knobs *l*.

If the knob *e* alone is pressed down, then both conductors are put direct to earth, and the galvanoscope is cut out.

If the knobs l_1 and *e* are pressed down together, the conductor L_2 is connected direct, and L_1 through the galvanoscope with the earth.

If, on the other hand, l_2 and *e* are simultaneously depressed, the galvanoscope is inserted between L_2 and earth, and the conductor L_1 is put direct to earth.

ELECTRO-MAGNETIC MACHINES FOR THE PRODUCTION OF CONTINUOUS INDUCTION CURRENTS OF SIMILAR DIRECTION.*

THE PLATE MACHINE.

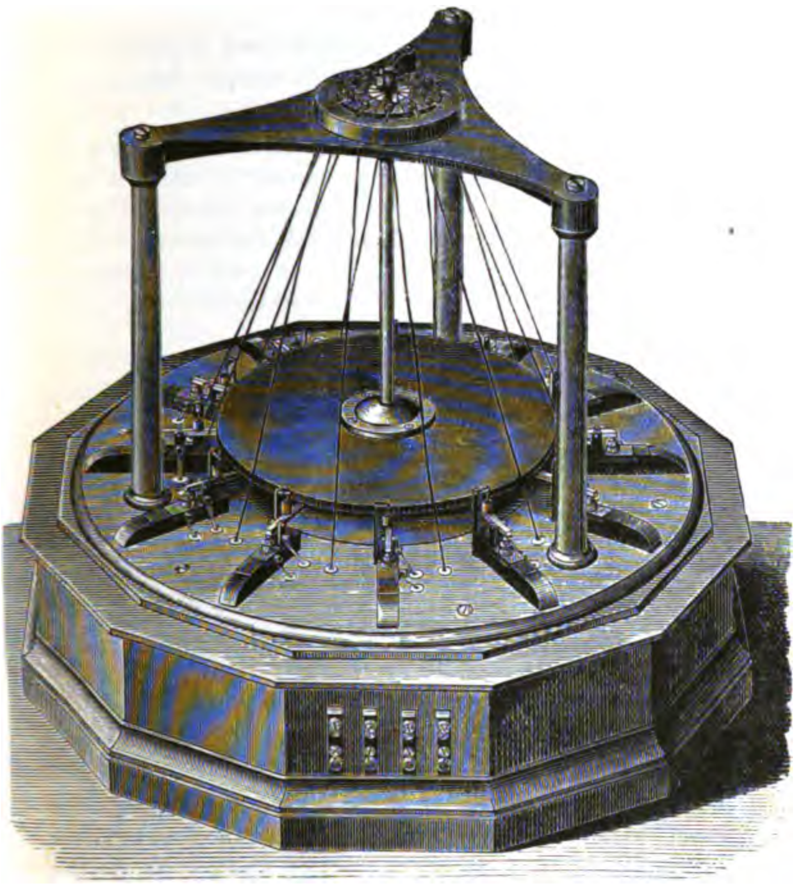
Preface.—The plate machine constructed in 1853, and sent to the Paris Exhibition in 1855, served—together with the automatic current generator described under II.—for the production of continuous currents of high potential requisite for telegraphing over long distances.

After telegraphing with alternate currents became possible, by the discovery in the year 1856 of the polarized electro-magnetic system, both machines lost their importance for telegraphy. An original description of the plate machine at the time of its introduction could not be found among the records of the firm of Siemens and Halske.

Halske described it quite shortly in a paper before the Polytechnic Society (see Proceedings for the year 1861, p. 375). The description given in what follows is taken from an article by Prof. E. Zetzsche on magneto-induction machines. (Dingler's Polytechnic Journal, Vol. 216, p. 491.)

* 1853 and 1855.

Fig. 52.



In Figs. 52 and 53 is shown the machine preserved in the Berlin Post Office museum, and the diagram of the circuits.

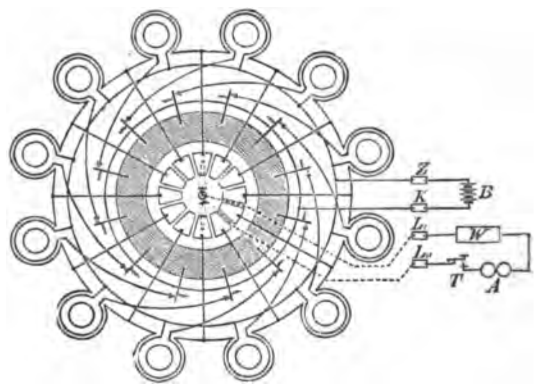
It has frequently been sought to obtain powerful currents of invariable direction, and as far as possible invariable strength, by so connecting two or more ordinary magneto-electric machines that the periods of the greatest strength of current of the one

machine as regards one magnet should correspond with the periods of weakest strength of the other.

This was very perfectly accomplished in a machine which Siemens and Halske of Berlin sent to the London Exhibition of 1851.*

In this machine a round iron disc (a plate) resting on a ball joint turns or spins in that peculiar manner in which a plate placed on its edge, and set spinning, moves shortly before its complete downfall; the plane of the circle lies somewhat lower than the ball, and the polar surfaces are cut down to a somewhat steep conical surface corresponding to the surface of a similar

Fig. 53.



cone which is swept out by the under surface of the plate. On the upper side of the plate a metallic arm projects perpendicularly from its centre lying above the ball, which owing to the motion of the plate also sweeps out a conical surface; the upper end of this arm gears into an arm fixed to the axis of a commutator, and so puts this axis in motion. The plate spinning in this way produces, in regular sequence, the closing or opening of contacts by means of which the current from an electric battery is always sent through one-half of the electro-magnets placed in the circle, and always just through all those electro-magnets which lie between the touching point of the plate with the poles of the

* See Preface.

electro-magnet in the direction of the motion up to the momentary highest position of the plate; the plate is itself magnetized by induction from the electro-magnets, but at the same time also maintained by the attraction on it of the electro-magnets in its rotatory and slowly-progressing motion about the poles. But each electro-magnet has also a second winding, and in this an induced current must, therefore, be set up on every appearance and disappearance of the current in the first winding. These second windings of all the electro-magnets are connected together in a continuous circuit, but at the point of junction of each two neighbouring windings the wire is led to the commutator in the form of a loop. Although the induced currents existing in all the electro-magnets, around which a current from the battery circulates, are generated by the production of the magnetism, while the induced currents existing in the electro-magnets around which no battery current circulates, are generated by the extinction of the magnetism, and are in the opposite direction to the former, yet by means of the commutator they are transmitted to the common conducting wires as a continuous current of one direction.

This method of connection and commutation possesses much similarity with that described as Pacinotti's, and in both there is the special division of the current into two branches. Siemens and Halske's machine was intended to produce with the help of a few cells an electric current of great strength which can be used for the service of long telegraph lines; by means of this machine telegrams were sent direct from Leipzig to Vienna viâ Munich.

II. Automatic Current Generator for Rectified Alternating Currents.*

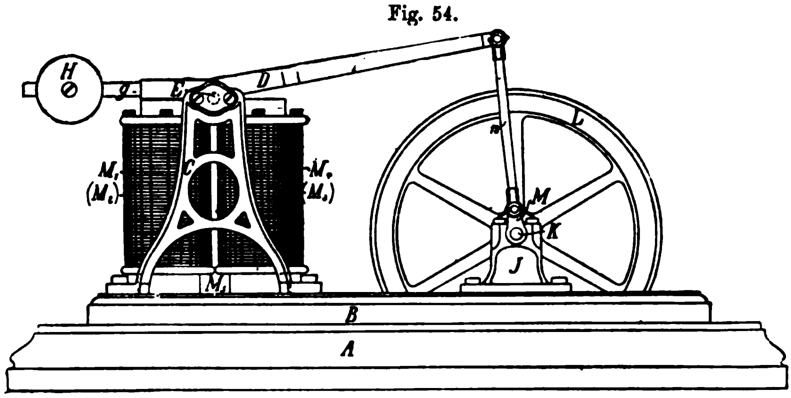
The apparatus (Fig. 54) stands on a base plate A of insulating material, and on this is a metal plate B, with two metal standards C C, supporting the axis E, with the armature D bent at an obtuse angle.

Below this armature are four electro-magnets $M_{1,\,2,\,3,\,4}$, with double windings placed upon a connecting frame M_5, fixed to the

* Patent specification of the 20th June, 1855.

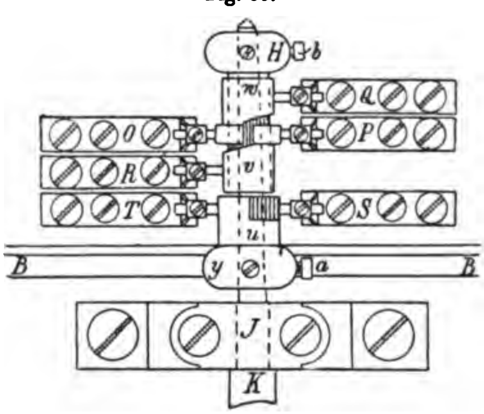
metal plate B. The armature D has an extension F on one side, which ends in a fork, to take the connecting rod *n*, on the other

Fig. 54.



side an extension *g*, which carries the weight H, to balance the longer arm F, together with the connecting rod *n*. There are also on the same base plate B, two bearings J J, which support an

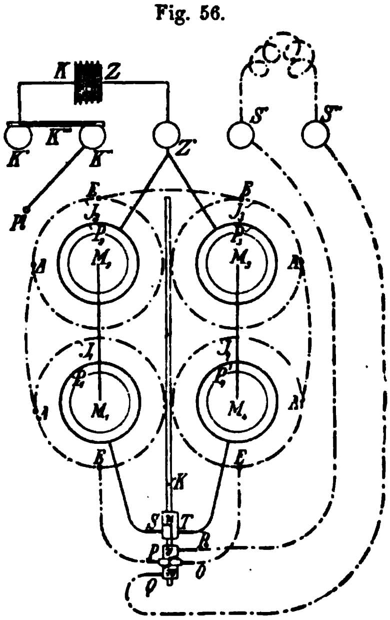
Fig. 55.



axle K, with a fly-wheel L. The axle K projects on the one side to take the crank M, which is joined to the connecting rod *n*; on the other side the axle K also projects to take the commutator arrangement, which is shown in Fig. 55 in three-quarters its actual size.

The commutator is made of cornelian and hard steel, and is divided into two parts. The first portion, fixed uninsulated on the axle, with the springs S and T, serves for alternating the primary current in the horse-shoe magnets M_1 and M_2 and M_3 and M_4. The second part consists of the insulated portions *v* and *w*, together with the springs O, P, Q, R, to give the galvanically-produced induction current similar direction without interruption. Fig. 56 gives the diagram of the circuits. The battery, con-

Fig. 56.



sisting of one or a few cells, is joined up between the binding screws K^1 and Z_1. K‴ is the contact-breaker, separated from K″ when at rest. S′ and S″ are those binding screws from which the useful current of high tension can be led away when the machine is at work.

If the battery is put in circuit by closing the lever K‴, and if the armature is balanced, that is equally distant from all four poles, the following is the course of the current: copper K′ K″, base plate Pl, axle K, commutator U, spring T, thick winding P_4

Fig. 57.

and P_3, of the electro-magnets M_4 and M_3, binding screw Z′, zinc; M_4 is a north, M_3 a south pole. The branch circuit at Z′, which leads through the thick windings of the two other electro-magnets, M_1 and M_2, is opened by the spring S, as it here rests on cornelian.

The limbs M_4 and M_3 will remain magnetic and attract the armature, until the crank M has turned the axle of the fly-wheel so far that the cornelian is in contact with the spring T; at this moment the spring S is in connection with the metal of the commutator *u*, and therefore with the axle, and the circuit for the magnets M_1 and M_2 is now closed; these now attract the distant armature and allow the axle of the crank to make another half-revolution, by which a reversal of the windings of the electro-magnets is effected.

By this play magnetism is successively induced in each two limbs, for instance in M_1 north, in M_2 south, in M_3 diminishing south, and through M_2 induced north, in M_4 diminishing north, and through M_1 induced south; in the next half-revolution, on the contrary, the same action takes place in the opposite direction. As the four electro-magnets are provided with fine windings, $J_{1, 2, 3, 4}$, a current must be induced in them and one always opposed to the first.

This alternating induction current is, however, changed by the commutator *vw*, which is like that of a Saxton machine, into a current of one and the same direction, and is thus made available for telegraphic and other purposes.

With the Morse telegraph this current-generator can be set in action without doing damage by the local battery of two or three elements, and then a machine four times as great as Fig. 54 gives a current of 60 to 90 cells, which still acts under the most unfavourable circumstances over a distance of 100 miles. The strength of the current is altered by making use of the induced current from 1, 2, 3 or 4 coils.

Postscript.—Besides the above described simple current-generator, the firm of Siemens and Halske also made one consisting of two such combined, the so-called "double automatic current-generator." An apparatus of this kind, preserved in the Berlin Post Office museum, is shown in Fig. 57.

APPLICATION FOR A PATENT FOR IMPROVEMENTS IN THE MORSE TELEGRAPH, RELATING TO ELECTRO-MAGNETS WITH REVOLVABLE CORE, TRANSLATION SPRING, ELECTRO - MAGNETIC DUPLEX SPEAKING AND AUTOMATIC STARTING.*

Our improvements in the Morse telegraph comprise the following :—

1. In place of the armature of the electro-magnet, we employ revolvable magnets ; we consequently do not use the force with which an electro-magnet attracts soft iron, but the force with which two electro-magnets oppositely polarized placed near to one another reciprocally attract each other. If one of these magnets together with its winding were made moveable, the inert mass to be set in motion by the magnetic attraction would be too great, and in consequence the motion would be retarded. Besides, the mobility of the windings would bring many technical difficulties in its wake.

We, therefore, construct the magnet so that the windings with the bobbin on which they are wound stand still, and the iron can turn in the fixed bobbin. Constructed in this manner, the moment of inertia of the turning portion is smaller than that of a moveable armature of ordinary construction. And specially we thus further obtain a much greater rapidity of attraction for equal strength of current and number of convolutions, and in this way it is possible to work much more quickly, and through a greater number of transmitting stations and with weaker batteries, than with apparatus provided with ordinary magnets.†

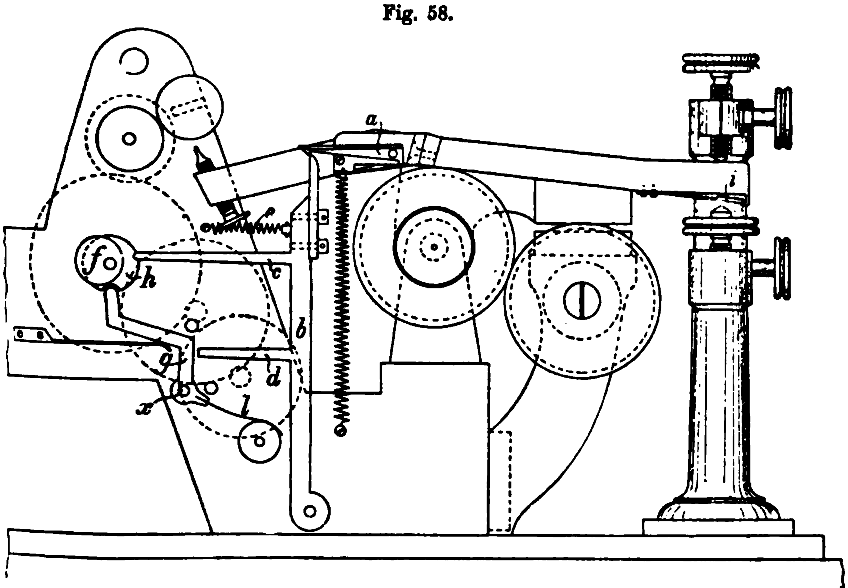
2. A second improvement in the Morse apparatus consists in the retardation of the working of the apparatus due to intermediate translating stations being done away with. The cause of this retardation is the duration of the contact of the writing magnet being always shorter than the duration of the current circulating in the windings of the magnet, *i.e.*, of the contact of the relay. At

* 20th January, 1855.

† The description of a relay with rotary magnets which here follows is omitted, because it already appears at pp. 104, 105.

each translating station, therefore, the duration of the action of the battery is shortened as regards the duration of the attraction of the writing magnet. The consequence is that with a great number of translating stations, the working must be done very slowly, particularly with long-spaced signals if the writing is to be legible. This inconvenience, which is already very troublesome through the great extension of the telegraph network, we

Fig. 58.



obviate very simply, as shown in Fig. 58, by making the contact I of the writing lever springy.

In consequence, the current begins in the line at the distant end of the conductor leading to the translating station somewhat before the completion of the approach of the writing magnet, and continues just so much longer after the backward motion of the writing lever has begun. The loss of time which is occasioned by the length of motion of this lever can thus be completely compensated, and retardation of the working through any number of translating stations ceases. As, further, the contact of the writing lever has been established before the style of the writing lever touches the paper, it is quite indifferent for translation whether a greater

or less loss of time takes place through the printing of the paper strip. The reading of through despatches at the translating stations causes, therefore, with our arrangement no disturbance, as was formerly the case.

3. A third improvement in the Morse telegraph consists in an arrangement of circuits by means of which it is possible, without alteration in the construction of the apparatus, to send despatches through one wire simultaneously from both ends. The current of the home battery is divided while speaking into two branches, each of which traverses one wire of the doubly-wound relay in such a way that these currents are equal and opposite. Their magnetising power is thus completely balanced. The branch current traversing the one wire goes through the line wire to the relay connected to this, and effects the writing there in the usual way. The other branch returns to the battery through a resistance formed of thin covered German silver wire. If signals are sent simultaneously from the other station, the balance of the home relay is disturbed by the battery there, and the relay magnets are magnetized by the difference of the strength of the currents. This arrangement differs from that of Dr. Gintl in that only one battery and a simple key is necessary; that moreover the necessary arrangement of the resistance is very simple and invariable; that the construction of the Morse apparatus remains unaltered; and that the arriving current passes unhindered even when the home key is suspended between the two contacts.

4. Our automatic starting and stopping is a decided improvement on the Morse apparatus. Its function is to start the clockwork as soon as a message is sent, and to bring it to rest automatically on the completion of the message.

If a message is sent, the first approach of the writing lever lifts up the steel hook *a*, the lever *b* with the two projections *c* and *d* follows the action of the spiral spring *e*, until the arm *c* is pressed against the eccentric disc *f* placed on the second axle.

At the same time, the arm *d* of this lever presses against a second bell-crank lever *g*, turning about the point *x*, and lifts the spring *l*, pressing on the fly with its lower arm, and thus releases the clockwork. At the same time the other end of the lever *g* is raised from the recess of the centric disc *h*, which is also fixed on the second axle. If by the advance of the clockwork the lever *b* is again raised

through the eccentric disc *f* by means of the arm *c*, the lever *g* during this time glides on the periphery of the centre disc *h*, and in consequence of this the spring *l* cannot touch the friction disc resting on the fly.

This only takes place when the hook *a* is not raised during a revolution of the second axle; and the lever *b* therefore is held fast when the eccentric recedes, and the notch in the disc *h* has advanced sufficiently for the end of the lever *g* to fall in.

By this arrangement 4½ inches at the most of unwritten Morse paper can pass through after the last given signal. This arrangement is essential to simultaneous telegraphing from both sides, for after the proper arrangement of his relay, the operator despatching has nothing to do as regards the arriving message, or the simultaneous control of his own message before his own work is completed.

We claim as our invention :—

1. The use in electric telegraphs of an electro-magnet revolvable in its fixed windings, instead of an armature of soft iron.

2. The application of a spring contact to the writing lever of the Morse telegraph, in order to increase the duration of the currents sent on through this contact.

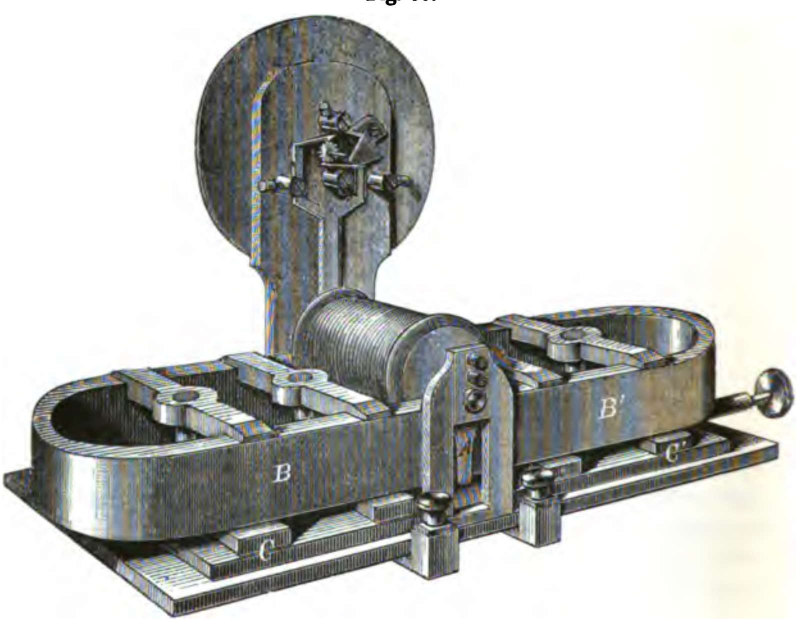
3. The method described for obtaining simultaneous speaking from both ends of a line, of dividing the current of the same battery into two branches, the magnetising action of which is completely balanced in its own relay.

4. The mechanism which automatically causes the complete release of the clockwork of the writing magnets by the first sign received, and the complete stoppage after the despatch is finished.

APPLICATION FOR A PATENT FOR A NEW MAGNETO-ELECTRIC DIAL TELEGRAPH. THE FIRST USE OF THE DOUBLE T ARMATURE (SIEMENS' ARMATURE).*

The pole pieces of an electro-magnet A (Fig. 59), capable of rotation within its bobbin, are situated between the opposite poles of two steel magnets B B'. The magnets carried on a slide C C', are

Fig. 59.

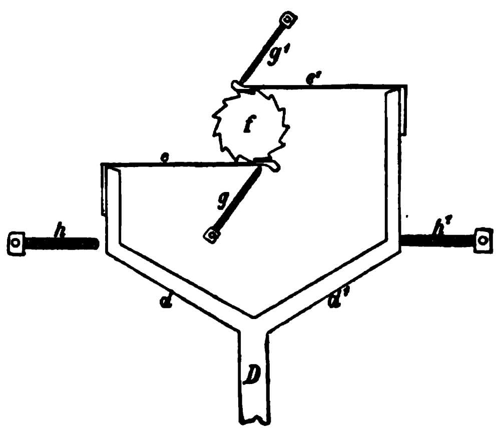


so arranged, that both exert an equally strong attraction on the electro-magnet acting as armature. To the revolvable magnet an arm D is fixed, which is continued into two arms *d d'* (Fig. 60), with the hooked springs *e*, *e'*. These hooks *e*, *e'* gear into the teeth of a small wheel *f*, which is turned through the length of a

* 6th June, 1856.

tooth by each forward and backward motion of the lever D. The hooks have beyond the catch a projection bent away from the wheel against which a screw g, g^1, presses when the motion of the arm ends by striking on the set screws h, h^1. In this way the forward motion of the wheel is stopped after rotating as far as is wanted, as may be seen from the detailed illustration of the wheel gearing. The axle of the wheel f carries the pointer. When a current passes through the conductor, and the windings of the magnet, the poles of the electro-magnet are attracted by one steel

Fig. 60.



magnet and repelled by the other, and in this way the wheel f is turned one tooth. If an equally strong current of opposite direction follow, the attraction and repulsion of the magnets are reversed, and a second forward motion of the pointer ensues, and so forth.

The equal and opposite currents necessary for the forward motion of the pointer are produced by means of a magneto-inductor specially represented in Figs. 61—63, and the construction of which differs essentially from constructions hitherto known. An iron cylinder E, shown in cross and longitudinal sections in Figs. 62—63, is provided as shown in the longitudinal section with two opposite grooves of a depth of $\frac{7}{16}$, and a width of $\frac{3}{8}$ of the diameter, so that it almost has the shape of a galvanometer

frame. This groove running round the length of the iron frame thus formed is so wound round with insulated copper wire that the cylindrical form of the iron bar is completed again by the windings. Two hollowed bushes are fitted to the axle, at the ends of the iron cylinder thus constructed which form the bear-

Fig. 61.

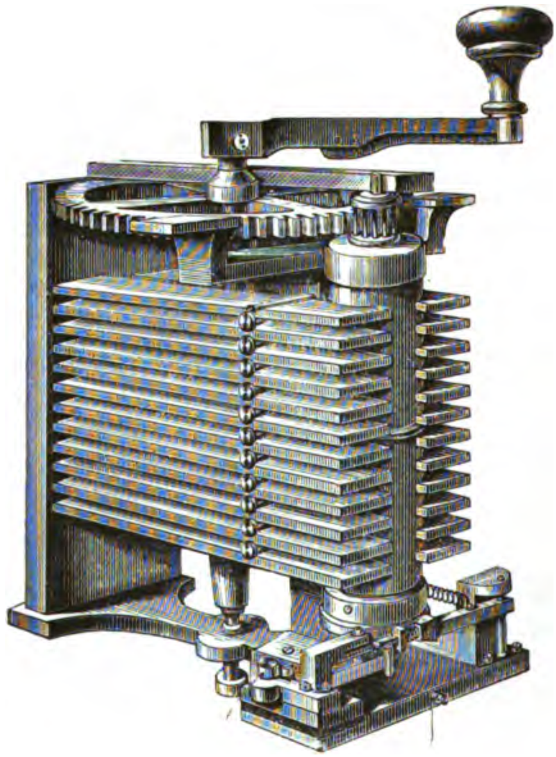
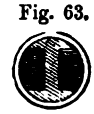


Fig. 62.

Fig. 63.



ings of the cylinder. This rotates between the poles of several small steel magnets laid above one another at a small distance apart. These magnets are formed of magnetized steel bars, which, where they surround the cylinder E, are hollowed out in the form of a segment of a circle, filled by the cylinder with but a slight clearance space. The other ends of the magnet

bars are connected by soft iron of the shape of horse-shoes. The cylinder E consequently serves as a common armature for all

Fig. 64.

the magnets. If the former be rotated, the magnetism in the inner flat iron core is reversed at each half revolution, and a current proportional to the amount of the magnetism is produced each time in the windings joined up into a conducting circuit.

The consecutive currents have alternate direction, and exactly equal magnetic value. The rotation of the cylinder E is effected by a driving wheel on the axis of which is the handle (H), Fig. 64, which rotates above the plate J provided with letters and numbers of the telegraph.*

The knob of the handle H can be depressed by a slight pressure of the hand. On its under surface a spring projection is fixed which then falls into the nearest of the notches which are cut on the rim of the plate, and the cylinder E is stopped. The ends of the wire coil communicate with the one end of the wire coil of the corresponding telegraph instrument (the other end of which is connected with the line), and with earth. The telegraph instruments thus connected up at both stations are consequently moved one tooth forward for each half revolution of the cylinder E.

To prevent the wire coil of the inductor from being unnecessarily traversed by the arriving current, a contact is arranged at the lower end of the cylinder E, by which the inductor is short-circuited, when the cylinder is in that position in which no current circulates in the convolution during the rotation.

The following are the advantages of the above-described magnetic inductor over those hitherto known :—

1. In the existing magnetic inductors four different currents are produced during a revolution, one on the receding of an iron pole from one magnet pole, a second of similar direction on approaching the other magnet pole, a third of opposite direction on receding from this, and a fourth also of opposite direction on approaching the first magnet pole. Stöhrer made the two currents on approaching and receding from one pole similar in direction by means of a commutator, and employed them in this way for magnetizing the electro-magnets. In the inductor described there are only two short but strong currents, and the commutator is entirely omitted.

2. The inertia of the rotating cylinder is for equal strength of the induced current hardly $\frac{1}{15}$ as great as that of Stöhrer's, Sinsteden's, and other constructions hitherto employed. The rotation of the cylinder can, therefore, be worked in the described

* Fig. 64 shows the form of the telegraph as it was in the year 1857. See "Transactions of the Verein für Eisenbahnkunde" of the 18th March, 1857.

manner by means of the hand without any trouble, or when it is preferred to use a clockwork and stoppage by keys, the rotation can be set at work without any further assistance by means of the clockwork.

3. Instead of employing two large magnets, an unlimited number of smaller ones may be used. As the carrying power of a magnet varies as the square root of the weight, much more powerful effects are produced with the inductor described with the same weight of steel. Hence by our mode of construction not only is the weight of steel saved, but the strength of the electro-magnetic current can be increased without limit, and without disproportionate increase of cost, which is not the case with the older constructions.

What we consider new and as our invention are :—

1. The construction of magneto-inductor described, especially the use of an iron core wound transversely, and capable of rotating round its longitudinal axis between the limbs of several steel magnets placed over one another.

2. The specially-described anchor escapement for turning the pointer wheel.

3. Placing the poles of our electro-magnet, movable in its fixed windings, between the opposite poles of two steel magnets in such a way, that the electro-magnet is held fixed in either of its two positions of rest by the preponderating action of one or other steel magnet.

APPLICATION FOR A PATENT FOR A METHOD OF TELEGRAPHING WITH MORSE WRITERS BY MEANS OF INDUCED CURRENTS OF ALTERNATE DIRECTION.*

We employ for our method translating devices (relays) which are so constructed, that the contact remains permanently on or off, without the help of a current passing through the line, when one or other position is mechanically brought about.

* 6th June, 1856.

We effect this—

1. By placing the poles of an electro-magnet between the poles of two permanently magnetized steel magnets, or electro-magnets, so that the rotary magnet is attracted towards both sides with equal force, when it is in the middle of the contact stroke, and consequently preponderantly attracted and held fast by the magnet to which it has approached.

2. By placing opposite to one another the poles of a rotary and of a fixed magnet, of which one is permanently magnetic, and by neutralizing the attraction of the latter by means of a spring, so that equilibrium between both forces takes place in the middle of the stroke. If short alternate currents of equal magnetic force pass through a relay arranged in this way, one direction of the current will magnetize the electro-magnets connected with the line in such a way that the movable magnet moves towards the contact, and the contact remains established until the second current of opposite direction reverses the magnetism, and permanently interrupts the contact. If the movable magnet described under 1 is placed between two fixed magnets, the motion of the former is caused by simultaneous attraction by the one side and repulsion from the other. If the relay is arranged as described under 2, the motion for contact is effected by the attractions of the permanent and temporary magnetism, the return by their repulsion together with the action of the spring.

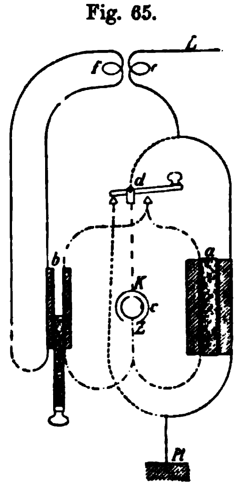
If both currents have exactly equal magnetic value, the one always completely annuls the action of the other, consequently, when once the position of equilibrium has been obtained there is never any necessity for correction, whatever the strength of the single currents may be.

We obtain the equal and opposite currents of very short duration which are required by the use of the currents produced by voltaic induction, as they are produced in the secondary coils of an electro-magnet by the closing and opening of the primary. By pressing down the key of the Morse apparatus, the current of a local battery of 2 or 3 cells is sent through the primary coils of a closed electro-magnet. The current induced thereby in the secondary coils of the same magnet magnetize the electro-magnets of the receiving station in the direction of the motion for contact.

The contact continues as long as the key is pressed down. By raising it the oppositely-directed opening current is set up in the secondary coils, which magnetizes the electro-magnet of the receiving station equally strongly in the opposite direction, and so brings about the breaking of the contact. If the apparatus are arranged for duplex, a second magnet, also with double winding, is inserted in the first series, the iron core of which is arranged to be drawn out.

The secondary coil of this second magnet communicates with

Fig. 65.

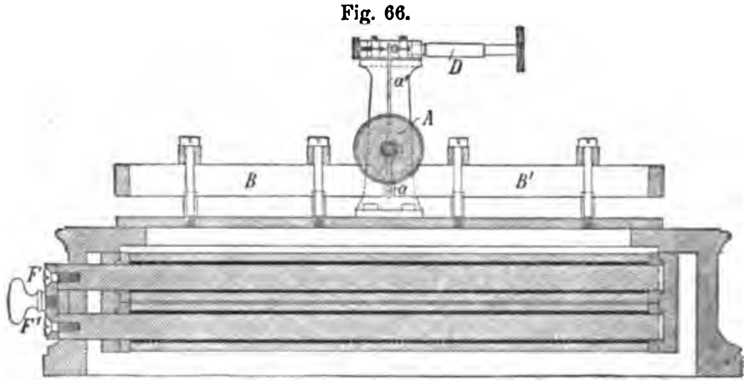


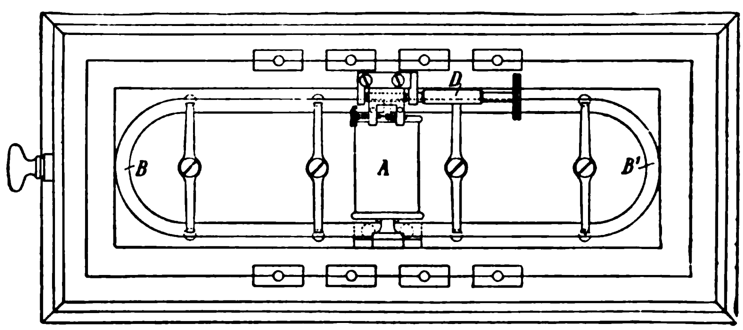
the duplex coil of the relay. If the iron core is now pushed down so deep into its coil that its own relay remains at rest when working, this is the correct arrangement for duplex speaking. This combination for duplex speaking is shown in diagram in Fig. 65 ; *a* is the volta inductor for the line current, *b* that for the duplex current. The primary coils of both inductors communicate with the battery *c* and key *d*. One end of the secondary coil of inductor *a* communicates with the line coil of the relay *e*, the other with earth. The two ends of the secondary coil of the local inductor *b* communicate with the two ends of the duplex coil *f* of the relay. To avoid the return of the entering current through the windings of the line inductor *a*, its two ends may be

connected with the key and back contact as represented by the fine dotted line.

In the annexed detailed drawings (Figs. 66 and 67) of a relay as described under 1 with line and local inductor, the movable magnet is represented by A, the polar extensions of which are

Fig. 66.





a, a^1, a^2, the two steel magnets by B, B^1. The contacts move forward together by means of the screw D, and the point where the attraction of both steel magnets is equal is hence very easily found: E E^1 represents the line inductor, F F^1 the local inductor for the duplex current in the case of duplex speaking. The advantages of this system are essentially—

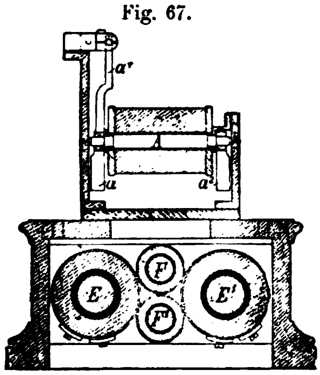
1. The troublesome use of the correction spring is quite obviated, because the relay must retain exactly the same position

with strong as with weak currents. One can consequently telegraph without any alteration with telegraph instruments, so arranged with the greatest safety at the greatest and least distances, and with great or small losses due to faulty insulation.

2. The costly line battery, which is besides the most usual cause of disturbances, is quite unnecessary. All that is necessary for telegraphing at any usual distance is the employment of the signalling battery consisting of 2 or 3 cells.

3. As only short but very powerful currents are used, these

Fig. 67.



telegraph instruments must be very insensible to disturbances of atmospheric origin.

4. By their use duplex speaking is rendered independent of rheostats, which are so little to be depended on. There is only one correction contrivance which is much easier to use than that of the usual Morse relay. Further, with the use of momentary currents, inserted magnets are no longer disturbing; duplex speaking can therefore be used with as many intermediate stations as desired.

5. As the induced currents used are of very short duration, it follows that the speed of signalling can be increased almost without limit. Therefore, both on this account, as well as the greater safety and invariability of the arrangement, quick writing or mechanical telegraphing can be carried on with safety with the new apparatus.

What we consider new and as our invention are—

1. Principally the use of induced voltaic currents in the manner described, *i.e.*, so that the closing current of the inductor produces the motion of the movable magnet which makes the contact for the local current, and its opening current in a similar way breaks the local circuit, or *vice versâ*.

2. The described construction of relay for Morse telegraphs with instantaneous currents.

3. The regulation of the strength of the duplex current, as regards distance, by a greater or less insertion of the iron core in the coils of the local inductor.

SIEMENS AND HALSKE'S INDUCTION WRITER. INSTRUCTIONS FOR ITS USE.*

I. *The Relay.*—We usually employ Morse or chemical writers with our induction writers. The relays are so constructed that the contact lever remains on the contact or on the insulated stop, when one or other position is mechanically given to it. This is effected by short induced alternating currents which pass through the line and the windings of the relay.

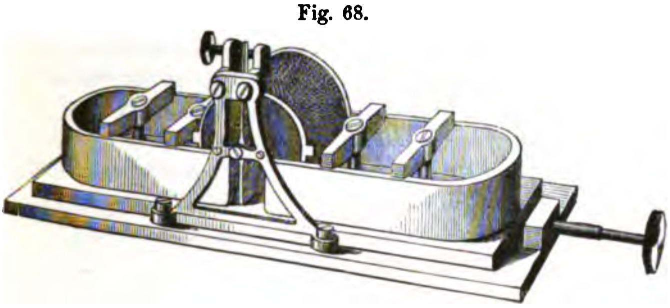
Two short currents following one another are, therefore, necessary for the production of each telegraph signal, of which one makes the contact, whilst the other of opposite direction breaks it again. The length of the dash produced is consequently not dependent, as in the Morse relay, on the duration of the current in the line, but on the length of the interval between the two momentary successive currents, during which no current passes. These momentary currents are produced by voltaic induction.

Two different constructions of relay are shown in Figs. 68 and 69, which we use for this purpose. In the relay shown in Fig. 68 the polar extensions of an electro-magnet, revolvable in its fixed bobbin, are so placed between the neighbouring opposite poles of two permanent magnets that they are attracted by both with equal force, when the contact lever is exactly between the contact

* 26th June, 1856.

and insulated stop. It is, therefore, held fixed by the preponde-

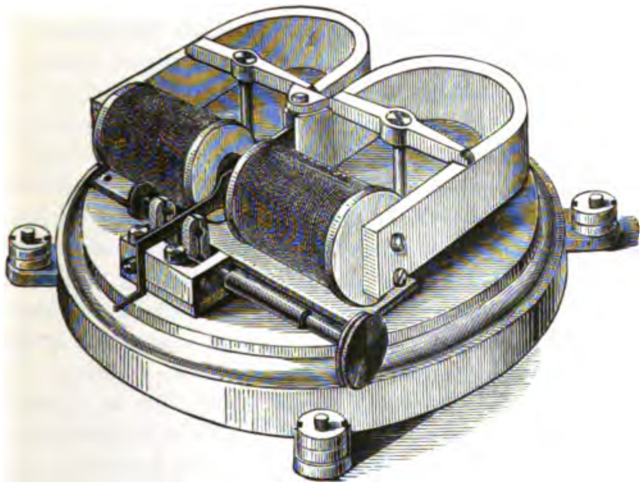
Fig. 68.



rating force of one or other magnet when it has passed the neutral point towards one or other stop.

If a current passes through the windings of the electro-magnet, the magnetism of the polar extensions attracts one and repels the

Fig. 69.



other permanent magnet. The equilibrium of the attraction is, therefore, disturbed, and with a certain direction of current a motion of the contact lever towards the contact takes place.

It is now held firmly against this latter by the preponderating

attraction of the corresponding steel magnet, strengthened by the remanent electro-magnetism.

The succeeding short current of opposite direction destroys the remanent magnetism, and gives the poles of the electro-magnets an opposite polarity, by which the return motion of the contact lever and its striking against the insulated stop is effected.

The relay shown in Fig. 69 has two fixed electro-magnets, whilst the permanent magnet is movable. Two similarly-named poles of the two curved steel magnets unite in a fixed iron piece, and in its hollow there turns with the least play an iron axle with its attached armature.

The latter, therefore, forms the movable extension of the two steel magnets, and in this way receives a very strong permanent magnetism.

The two other similarly-named poles of the magnet carry the electro-magnets, opposite to the poles of which the armature stands. When no current circulates in the windings of the electro-magnets, the ends of the electro-magnets constitute equal permanent magnetic poles, and exert on the oppositely magnetic armature a very powerful attraction equally strong in both directions. If a current flows through the windings of the electro-magnet, this equilibrium is disturbed, and the armature is moved in one or other direction according to the direction of the current. By the joint action of the preponderating attraction of the nearest permanently magnetized electro-magnet and of the remanent magnetism, the armature is retained after the cessation of the current until a current of opposite direction circulates, and causes the motion towards the other stop. There is, as a rule, no fear of an injurious influence on the permanent magnetization of the steel magnets with the small quantity of electro-magnetism employed when the magnets are made of glass-hard steel.

In cases where very strong currents may have to be used, as, for instance, with magneto-electric needle telegraphs, or with relays which are to work on very short lines, we make use of a third construction of relay, the chief difference of which from that just described is that instead of the two separate electro-magnets a horse-shoe magnet is used.

The relays described may also be used as ordinary Morse relays. It is only necessary in this case to advance the contact piece so far

by means of the screw that the equilibrium of magnetic attraction is permanently disturbed. The near magnet then works as a spring, the action of which, as regards the strength of the current, may be modified at pleasure.

Any ordinary Morse relay can equally be used for signalling with induced currents, if the armature or pole of the rotary magnet is set very near, and the spring made weak. The remanent then takes the place of the permanent magnetism. Naturally, the certainty and sensitiveness of the relay is considerably less in this case.

II. *The Inductor.*—We construct the volta inductors, by means of which short currents of alternating direction are produced, in the following manner :—

The iron core of the inductor is a thick iron plate with upturned flanges. This is wound first with the primary coil formed of thick wires, and then with the secondary coil, until the space between the core and the flanges is completely filled with wire.

Two or more bobbins thus formed are now placed upon one another, and the primary and secondary coils are so connected that each two bobbins form a closed horse-shoe magnet. The advantages of this mode of construction are :—

1. The horse-shoes are short-circuited ; and a greater magnetism is therefore produced with them than with open magnets; and

2. Each limb of the horse-shoe exerts its full effect on all enclosed wires, the windings of the one iron core are therefore subjected to the inductive action of the other.

Inductors of this class can therefore be made much smaller for equal effect than those of other construction, and require a considerably smaller quantity of wire for the production of currents of equal strength.

III. *Connections.*—Of the many possible connections for simple signalling, we will only mention those below, numbered 1 to 5, Figs. 70—74.

In all of them L is the line, *w*1, *w*2, the two windings of the relay, T the key, with the contacts *a*, *b*, and *c* ; B the battery of two cells; P the primary, S the secondary coil of the inductor (in connections 2, 3 and 5, shown separated), and E the earth plate.

Connection 1 (Fig. 70).—On pressing down the key T, after the back contact *a* is broken, and before the working contact *b* is

made, the connection of the free end of the secondary coil S, of the volta inductor is made with the key T and the line by means of a third contact *c*, and thus opens a path to it for the secondary current arising after the closing of the local circuit.

After the interruption of the local current, at the commencement of the backward movement of the key, this connection of the secondary coil with the line continues for a short time, owing to the spring contact. As the secondary currents endure for a very short time, this short closing of the line is sufficient to

Fig. 70.

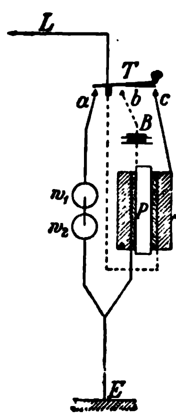


Fig. 71.

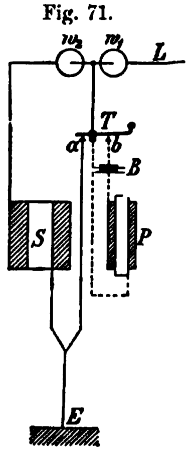
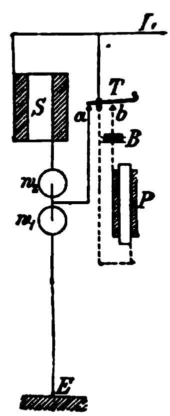


Fig. 72.



effect the return motion of the contact lever of the relays that are inserted.

Connections 2 and 3 (Figs. 71 and 72).—Instead of the third spring contact to the key (or writing lever in the case of relays), the keys with two contacts hitherto used can be employed in the manner shown in the diagram. The relay must for this purpose be wound with two equal and equivalent wires. For the sake of clearness, the wires *w*1 and *w*2, wound on the same iron core, are shown separate, but near to one another in the figures.

The course of the current in Fig. 71 is such that the entering current only flows through one of the relay windings, *viz.*, *w*1, and then goes through the back contact *a* of the key 1 resting on it to earth E. The current passing from the inductor traverses, on the contrary, both windings of the relay in turn, and in such a

way that the actions of the currents in the two windings balance each other.

If now the two wires, $w1$ and $w2$, are simultaneously wound and of similar lengths, the compensation for every strength of current is complete, consequently the outgoing current cannot work its own relays.

The action is quite analogous with the arrangement shown in Fig. 72.

The arriving current takes the road L, T, a, $w1$, E the outgoing current E, $w1$, $w2$, S, L, at one time in one and then in the opposite direction.

Connection 4 (Fig. 73).—The relay R, wound as usual with

Fig. 73.

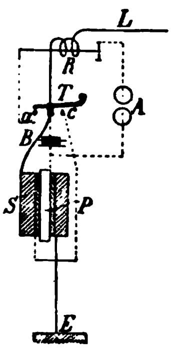
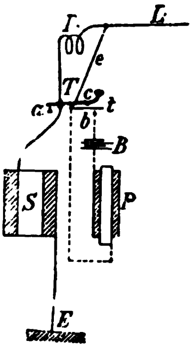


Fig. 74.



one wire, works when sending, but the writing apparatus A does not, because on pressing down the key T the local circuit is broken at a, even if it should be closed at c.

Connection 5 (Fig. 74).—Here also only two contacts, a and c, are used; on the other hand, a second lever or a spring t is applied.

The arriving current takes the course L, R, T, S, E. If the key T is pressed down it comes first into conductive connection with the smaller lever t, and then afterwards through this with the battery contact. The current thus induced passes through the wire e direct into the line. If it is supposed that with the returning motion the contact with b is raised, and the lever T still in contact with t, there remains for the induced opening current the way E, S, T. c, t, e, L.

The relay is consequently withdrawn from the actions of the outgoing currents.

IV. *Advantages.*—The advantages which our induction telegraph presents consist in the saving of line batteries, in obviating the troublesome relay adjustments, and in its not being affected by deficient insulation, and considerable length of the lines. It must also be specially mentioned that the new apparatus permits of being combined with those existing without any disturbance; they can both transmit writing to them as well as take it from them, and also be employed as relay with an old one. The change from the one system to the other is thus much simplified.

REMARKS ON DR. MOHR'S PAPER ON THE INEFFICACY OF THE TRANSATLANTIC ELECTRIC CABLE.*

Dr. Mohr has expressed the opinion in this journal (Vol. 150, p. 285) "that the laying of telegraph cables in great ocean depths is impracticable with the technical appliances at present existing, since the great pressure of the water must penetrate the substance of the insulator, and in time destroy the insulation."

This opinion is fortunately quite incorrect, and in no way founded either on theory or practice.

Dr. Mohr does not take into consideration that gutta-percha is an elastic not a porous body. It is very clear that flasks filled with air, and the pores of wood filled with air, become filled with water, when placed under a very great hydrostatic pressure, as the air is compressed to a very small volume under the pressure of many hundred atmospheres, the water must therefore replace the air in the pores. As water absorbs gases existing under high pressure much more readily than those existing under low pressure, it is also very conceivable that the air in the inverted flasks, and existing in the pores of the wood before immersion, apparently quite disappears; and that after the return of the flask or of the wood from a great depth, hardly any more air is to be found in

* Dingler's Polyt. Journ. Vol. CLI. p. 380, 1859.

them, the water having absorbed it under the high pressure. But it is quite otherwise when bodies which have no pores, and elastic bodies, the pores of which are not in direct connection as in wood, are placed under a high pressure.

A bladder filled with air will be compressed under external hydrostatic pressure until equilibrium exists between the air pressure in the interior and the external water pressure; it will not therefore be penetrated by the water, and contains after removal of the pressure the same quantity of air as previously. Very elastic gutta-percha acts in the same way. If there should be non-connected pores in its interior also filled with air, they would diminish their volume under high pressure, until the air in their interior balanced the external pressure, but would not become filled with water. That the homogeneous mass of the gutta-percha cannot itself be penetrated by water is undoubted, and is not called in question by Dr. Mohr. Dr. Mohr describes quite accurately the process invented and employed by Halske and me in 1847, of covering wires with gutta-percha, and of discovering the damaged places by means of induced currents. This is still employed in exactly the same manner, in the manufacture of submarine cables; the repair of the injured places thus discovered is not effected by a superficial closing up of the pores, but by a softening of the whole gutta-percha covering. Besides, with submarine lines a single coating is not considered sufficient, but the wire covered with a fully insulating coating is again covered with a single or double coating of gutta-percha; there can therefore be no question of pores, leading right through from the surface to the wire, if no violent accident has occurred. Besides, all wires before being covered with a sheathing of hemp and iron are tested under as high a pressure as the hydraulic press can give, whereby hitherto an injury to the insulation has become apparent only in very few cases. I pass over the opinions brought forward by Dr. Mohr on the rapid propagation of the electric current, which he bases on the certainly irrelevant Wheatstone experiments, as they have long since been proved incorrect; by reading my memoir on electrostatic induction (Pogg. Ann. Vol. CII., p. 66), he could easily set his opinions right. Now, as to the reasons why the trans-Atlantic cable does not work as desired there are:—

1. The imperfect insulation of the gutta-percha itself.

2. The great tension to which the wire must have been exposed during the laying.

3. The small section, and therefore the slight conductivity, of the strand of copper wires, and

4. The unprofitable use of the cable after laying. It would appear, and is besides very probable, that there are no perfect insulators anywhere. Gutta-percha certainly conducts electricity very slightly at low temperatures; but owing to the great length of the wire, and its proportionately very slight conductivity, scarcely a fourth of the current could be obtained at the other end of the wire, even assuming that the temperature of the sea bottom is probably about 3° to 4° C., and that the gutta-percha is perfectly homogeneous and as insulating as possible. Under these circumstances it would, however, have been possible to telegraph well; but on its way to the sea bottom the cable had to be kept back by a force which balances the weight of a piece of cable hanging down perpendicularly in the water to the sea bottom; as otherwise the cable would have quickly glided down into the depth along the inclined plane formed by the water itself. But with the kind of armouring adopted, consisting of iron wire, this load exceeds already at 10,000 ft. the limit of elasticity of the cable. During the laying therefore, a considerable permanent stretching of the cable must have arisen, whereby all the air bubbles in the gutta-percha would have been enlarged, the inner connection of the different layers separated, and so faults of continuity in the gutta-percha covering harmless until then, considerably aggravated. In the majority of cases the great external pressure has acted advantageously, and has again closed up such discontinuities as have occurred. It thence appeared very likely in advance that in many cases the so advantageous counter-effect of the increased external pressure would not suffice, and that the insulation would be considerably injured in laying, as was indeed the case. It could also be assumed with certainty that, irrespective of this permanent lengthening, the insulation would be somewhat worse after than before the laying, owing to the great pressure compressing the gutta-percha, and thereby diminishing the thickness of the insulating layer, and because the tarred hemp, which so long as it is dry contributes somewhat to the better insulation, is by degrees saturated with water, and the air contained in it absorbed by the same.

If the cable, after laying, had been managed at first with more care, it is probable that in spite of all these causes it would not have become quite unserviceable. But instead of placing the wire for a long time in connection with the positive pole of powerful batteries, so as thereby to reduce the conductivity of the gutta-percha to a minimum, and to fill up small existing pores with copper oxide (a process which we have frequently used with great success in the earlier underground lines, and which was brought into very successful use for the cable in the Lake of Constance by Mr. Hipp, and for the Mediterranean cables by ourselves), strong induced currents of very high potential and alternating direction were at once sent through the cables, and small pores were thereby enlarged into great faults of insulation which could not be repaired.

Even immediately after laying, the cable had not been for a moment in serviceable condition. It had certainly been possible, with mirror galvanometers of great sensitiveness, to observe weak currents which had traversed the line, and even from such deflections of the mirror to the right or left, scarcely perceptible to the naked eye, to decipher some very slowly-sent words, but at no time has it been possible to receive decided signals with regular telegraphic instruments.

But even the highly imperfect method of communication mentioned above soon stopped, in consequence of the deterioration of the line which took place.

Very slight currents can still traverse the cable ; it is, however, not possible to use them, for they are considerably exceeded in strength by the currents of alternate strength and direction existing in the cable without external cause, and probably due to variations in the intensity of the earth's magnetism. I have often observed such currents in underground conductors running from East to West, and especially in a very high degree whilst there was an Aurora Borealis in the sky, at which time, as is well known, the intensity and direction of the earth's magnetism are subjected to very quick and strong fluctuations.

The hypothesis of Dr. Mohr, that the deterioration of the insulation of the Atlantic cable should be a necessary consequence of the great pressure—an assertion which, if it were correct, would make all submarine telegraphy problematical—is fortunately

neither correct nor necessary for the explanation of the failure of the Atlantic cable; its improper construction, and its even more improper use, perfectly explain this total failure.

The Mediterranean cables, which Dr. Mohr brings in support of his opinion, prove just the contrary. The line from Cagliari to Malta and Corfu, which passes through sea depths not much less than the Atlantic cables, was quite well insulated a year after submersion, and only slightly worse than before submersion, although with these lines also induced currents were employed for telegraphy. The first deep sea line successfully laid, the line between Cagliari and the African coast, consisted of four very thin wires, covered with gutta-percha, which were enclosed in a common iron sheathing.

This heavy cable was likewise exposed to a tension exceeding its limits of elasticity, in consequence of which all four conductors were damaged. Nevertheless, we succeeded by positive polarization in putting all four into serviceable condition. One of these lines was used regularly with positive currents, and the result was that after six months the faults of insulation completely disappeared. The three other wires remaining unused, are, on the other hand, still in their original condition, *i.e.*, only serviceable with the use of positive currents. As it appears there are circumstances, the causes of which do not lie in the line of engineering, which in this case precluded the exclusive application of positive currents. It follows from the nature of things that submarine lines, both as regards laying and maintenance, will always be exposed to considerable insecurity. In calculating the profitability of such work, the slow propagation of electricity through long lines has besides to be considered as an important factor; in consequence of which the despatch of messages is also slow; yet the lines already laid sufficiently show that even lines of the length of the Atlantic cable are technically practicable, and can be kept in undisturbed efficiency for a length of time. As the retardation of the electric current increases as the square of the length, and diminishes on the other hand with the square of the diameter of the conducting wire, the workability of long lines can be increased as desired by a greater expenditure of copper and gutta-percha. The difficulty of laying at very great depths may also be overcome by a suitable construction of the cable and the laying machinery.

It is to be hoped that the submarine cable from Suez to Calcutta, now in course of manufacture, which is nearly twice as long as the unfortunate Atlantic cable, will furnish practical evidence that great sea depths and distances are not technically insurmountable.

DESCRIPTION OF A CONSTANT GALVANIC BATTERY, 1859.*

Halske and I have been for a long time engaged on the problem of constructing a constant battery, so that the action continues for a long time unimpaired, and the inconvenience and other disadvantages arising from the unavoidable use of two liquids separated by a porous diaphragm disappear. As is known, all batteries in which both metals stand in the same liquid, as, for instance, the zinc-carbon batteries recently so much used, do not give a current of constant strength. At the moment of closing batteries of that kind the current is strongest; the current considerably diminishes after the first few seconds, and sinks when continuously closed to from a half to a third of its original strength. If the battery subsequently remains for some time on open circuit, it gradually regains its original potential. It is clear that this continual and considerable falling-off in the strength of the current must be of very great disadvantage in telegraphy, and such imperfect means would certainly not be made use of if constant batteries did not possess other and very important defects.

Grove's and Bunsen's batteries are only in a few cases available for telegraphic purposes, as the nitrous acid produced by the decomposition of the nitric acid is very injurious to the health, and spoils the apparatus in a short time. Batteries in which the liquid submitted to electrolysis consists of a solution of bichromate of potash, chloride of mercury, oxide of manganese, etc., have not proved practical. It therefore only remained to consider the Daniell battery.

* Journal of German-Austrian Telegraph Society, Vol. VI., p. 53.

This is cheap to make and maintain, has a much greater electromotive force than the zinc-carbon battery, and gives currents quite constant in strength.

On the other hand, the Daniell battery is very inconvenient to maintain, and easily altogether destroyed if the necessary attention is not devoted to it. This arises to a great extent from the imperfect action of the porous diaphragm, by which the solution of sulphate of copper is separated from the dilute acid, and the zinc placed in it. Both the porous clay pots usually employed, and the other materials formerly used as porous diaphragms, permit of the admixture of the liquids by diffusion. The sulphate of copper thus carried to the zinc is decomposed by the zinc, sulphate of zinc is formed, and the copper is precipitated on the zinc. Hence in the first place copper sulphate, and zinc are uselessly consumed ; further, the action of the battery is considerably reduced owing to the copper being deposited on the zinc ; and finally the porous vessels become quite useless, as they are covered with galvanically-separated copper, and are quite corroded by it.

It has recently been sought to remove the porous diaphragm entirely, as it was considered that, owing to the solution of sulphate of copper being always kept saturated by a glass funnel, its greater specific weight would always keep it separated from the acidulated water above it.

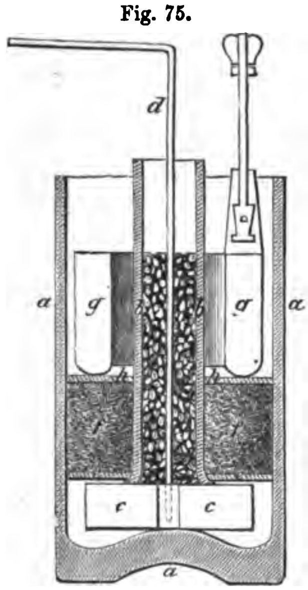
As, however, sulphate of zinc is formed by the action of the electric current, which increases the specific gravity of the acidulated water, as further the mixture of the liquids is certainly considerably diminished, but not entirely prevented by the difference in specific gravity, and as currents exist in the liquid in consequence of the electric current itself, and other causes which further promote their mixture, it follows that from this arrangement no satisfactory result is to be expected.

The only means of removing the faults which have been mentioned in connection with the Daniell battery, appears to lie in the improvement of the diaphragms. Halske and I, after many experiments with materials unaffected by concentrated sulphuric acid, have found a material which possesses in a high degree the properties required of diaphragms. Daniell batteries supplied with diaphragms of this material have kept quite constant.

The intermixing of the liquids has been entirely prevented by it, the action of the battery keeps constant for many months, and no chemical consumption of sulphate of copper and zinc takes place in it.

Figure 75 gives a vertical section of such a cell: *a* is the glass vessel, *b* is a glass tube somewhat widened below, *c* an upright strip of sheet copper bent into several spiral windings, *d* a wire fixed to it, *e* is a thin pasteboard disc, *f* the diaphragm

Fig. 75.



of paper pulp, *g* a ring of zinc with clamp. The paper pulp from the paper factory is well pressed, and afterwards saturated with a fourth of its weight of English sulphuric acid, and stirred up until the whole mass has attained a homogeneous sticky condition.

It is then mixed up with a fourfold quantity of water, and freed in a press under heavy pressure from the superfluous acid water, and formed into ring shaped discs, which quite fill up the space between the glass walls.

When the cells prepared in this way are to be set in action the inner glass cylinder is filled with crystals of sulphate of copper,

water is then poured in, and the ring formed space also filled with water, to which on the first filling some acid or common salt is added. Afterwards it is only necessary to see that the inner glass cylinder is always kept full of pieces of sulphate of copper, and that the water in the outer vessel is renewed from time to time, so that the sulphate of zinc formed by the current may always be kept dissolved. The sulphuric acid necessary for the formation of the sulphate of zinc is carried by the current through the diaphragm itself, and thereby the free sulphuric acid from the decomposed sulphate of copper simultaneously removed.

This is of great importance, as otherwise the solution of sulphate of copper would retain too much sulphuric acid, and the solubility of the sulphate of copper be much diminished thereby. According to the experience gained with such batteries during six months' working their action is exceedingly constant. The cost of maintenance is very small, as all chemical consumption of sulphate of copper and zinc is obviated.

Such a battery can be left for months without injury to its action, if care is only taken that pieces of sulphate of copper are always visible in the glass tube, and that the evaporated water is renewed. It is well to take down the batteries every fortnight, to clean the zinc cylinder thoroughly, to pour off the liquid, and to renew with pure water. If the sulphate of copper employed contains iron, it is well to turn the batteries upside down, so that the solution of sulphate of copper below the diaphragm, which then contains much sulphate of iron may be removed.

The zinc rings should not be amalgamated. In order to remove the foreign metals contained in the zinc, which remain undissolved, from the paper, we protect this with a ring of some loose texture, which is replaced on cleaning the battery by a new one. This can be easily made serviceable again with dilute nitric acid, which removes the metals remaining undissolved.

In filling again with water, care has to be taken that the space under the diaphragm is completely filled with water. If air bubbles appear, they can easily be removed by tilting the glass. The resistance of cells of this kind is not much greater than that of the usual small Daniell batteries with hard-baked earthenware pots. They are, therefore, suitable for all line batteries, but have, as a rule, too great a resistance for local batteries.

Remark.—The battery described above is now known under the name of Siemens and Halske's, or Paperpulp battery, and is in extensive use. A recent modification of the same is the Kieselguhr cell, of Siemens and Halske, in which the diaphragm is formed of Kieselguhr (infusorial earth), which is saturated with sulphuric acid.

SIEMENS AND HALSKE'S APPARATUS FOR WORKING LONG SUBMARINE CABLES.*

From the papers of Faraday, published at the time in this Journal (vol. i. p. 126 and vol. ii. p. 101), of Werner Siemens (vol. i. p. 137), and of Wheatstone (vol. ii. p. 152), it is known that a telegraph cable lying on the sea-bottom behaves like a Leyden jar of very considerable surface, the copper conducting-wire being the inner coating, the gutta-percha covering acting as the glass of the jar, and the protecting iron sheathing together with the surrounding water, acting as the outer coating.

If one end of such a cable is connected with the free pole of an earthed battery whilst its other end is insulated, then a galvanometer inserted between the battery and cable, indicates by a considerable but decreasing deflection the charging current entering into the cable; if the cable is then disconnected from the battery and put in connection with earth, the discharging current from cable to earth shows itself by a deflection in the opposite direction.

The same thing occurs, if the further end of the cable is not insulated, but connected to earth. Then also a charge takes place, in the first instance, when the pole of the battery is connected up; and only if the connection be maintained is the current at the other end of the cable perceptible on a galvanometer or other telegraph apparatus inserted there between it and the earth. If then the connection with the battery is interrupted, and the corresponding end of the cable insulated, the current does not

* Journal of the Deutsch-österr. Telegraphen Verein, Vol. VI., p. 96, 18

instantly cease at the other end, but continues for some time, though gradually becoming weaker, because now the discharging current travels in the same direction as the battery current, and immediately follows it.

These charging phenomena cause frequent disturbances in signalling on such lines, and render necessary many special contrivances and alterations in the construction of the apparatus, because, with the ordinary apparatus used on overhead lines, it would only be possible to signal very slowly through submarine cables, and not at all through long lines.

In what follows the system of apparatus is described, which Siemens and Halske constructed, having regard to the requirements of long submarine lines, and which were first used on the submarine line in the Red Sea from Suez to Aden, carried out by them in connection with the well-known English firm of Newall and Co.*

THE PRINCIPAL LAWS OF CHARGING CURRENTS.

Werner Siemens has brought forward and verified the following among other laws having reference to the charge.

If Q represents the amount of charge, and α the angle of deflection, then—

$$Q = \sin\frac{\alpha}{2} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1).$$

If now it is desired to compare the charges Q and Q_1 for two different wires, and if the respective deflections δ and δ^1 have been found by means of a tangent galvanometer, the ratio of the charges is given by the proportion—

$$Q : Q_1 = \sin\frac{\delta}{2} : \sin\frac{\delta_1}{2} \quad . \quad . \quad . \quad . \quad (2).$$

A means of comparing the charges by calculation is given by the proportion—

$$Q : Q_1 = \frac{n\,l}{\log\frac{r}{\rho}} : \frac{n_1\,l_1}{\log\frac{r_1}{\rho_1}} \quad . \quad . \quad . \quad . \quad . \quad (3),$$

* This paper was written by Werner Siemens with a view to its being translated into English, and forming a part of the instructions, which have since appeared in print, intended for the officials of that line.

in which,

$l\, l_1$ represent the lengths of the wires,

$r\, r_1$, the corresponding radii of the gutta-percha,

$\rho\, \rho_1$, the corresponding radii of the copper wires,

$n\, n_1$, the relative electro-motive force, or the number of cells.

Very important consequences follow, moreover, from this equation. If it is assumed, for instance, that the ratio $\frac{r}{\rho}$ of one cable is equal to the ratio $\frac{r_1}{\rho_1}$ of the other, then—

$$Q : Q_1 = n\, l : n_1\, l_1 \quad . \quad . \quad . \quad . \quad . \quad (4).$$

If it is farther assumed, that in both cables the same number of cells are used, *i.e.*, that $n = n_1$, then—

$$Q : Q_1 = l : l_1 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (5).$$

But if the lengths of the cables were the same, *i.e.*, if in (4) $l = l_1$, then—

$$Q : Q_1 = n : n_1 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (6).$$

If it is farther assumed that t and t_1 are the times, after which the charging current appears at the end of the two cables, then the ratio of these times is given by the proportion—

$$t : t_1 = \frac{l^2}{\rho^2 \log \frac{r}{\rho}} : \frac{l^2_1}{\rho_1^2 \log \frac{r}{\rho_1}} \quad . \quad . \quad . \quad . \quad . \quad (7);$$

and for the case again, that $\frac{r}{\rho} = \frac{r^1}{\rho^1}$

$$t : t_1 = \left(\frac{l}{\rho}\right)^2 : \left(\frac{l_1}{\rho_1}\right)^2 \quad . \quad . \quad . \quad . \quad . \quad (8);$$

and when, moreover, in (8) $l = l_1$

$$t : t_1 = \rho_1^2 : \rho^2 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (9).$$

Or, if instead of this $\rho = \rho_1$, then

$$t : t_1 = l^2 : l_1^2 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (10).$$

From the above equations there follow the following important laws:—

a. The charges are proportional to the sines of half the angle of deflection.

b. When the ratios of the thickness of the gutta-percha covering to that of the copper wire are the same, the charges are only dependent on the lengths of the cable and the number of cells in the batteries, and then they vary according to (4) as the product of the lengths of the cables and the number of cells.

c. If the ratio of the thickness of the gutta-percha to that of the copper wire is the same in both cables, and the batteries are also equal, then, according to (5), the charges vary as the unequal lengths of the cable.

d. If the ratio of the thickness of the gutta-percha to that of the copper wire is the same in both cables, and the lengths of the cable are also the same, then, according to (6), the charges vary as the number of cells in the unequal batteries.

e. The times of charge are independent of the batteries, as the latter do not appear in the determining equations 7 and 10.

f. If the ratio of the thickness of the gutta-percha to that of the copper wire is the same, the times of charge are only dependent on the lengths of the cable and the thickness of the copper wire, and vary according to (8) as the squares of the quotients of the length of the line by the radius of the copper wire.

g. If the ratio of the thickness of the gutta-percha to that of the copper wire is the same in both cables, and if the lengths are also the same, then, according to (9), the times of charge vary inversely as the square of the radius of the copper wires employed.

h. If the ratios of the thickness of the gutta-percha to that of the copper wire are the same in both cables, and the copper wires are equally thick, then, according to (10), the times of charge vary directly as the squares of the lengths of the cable.

With the help of these laws, it is easy to deduce from the measured charge and retardation of one submarine cable the amount of the charge and retardation of another.

To calculate the speed with which telegraphic signals can be sent through a certain line, another condition arises—the formation of electric waves in the wire of the cable which Faraday first observed. As follows from the above the charge of the whole wire precedes the appearance of the current in the measuring or telegraph instruments placed at the further end of the line.

But if the connection with the line of the free pole of one of the batteries, the other pole of which is to earth, is interrupted,

before the current has commenced at the end of the line, the static electricity previously collected in the wire extends over the whole wire, and the current commences in the measuring instrument after a certain time, although the battery is no longer operative.

If the battery is reversed, instead of being interrupted, then the part of the line lying nearest to the battery is charged with opposite electricity.

The electricity still present in the distant portions of the line from the preceding charge flows in both directions, and therefore partly through the instrument, but it partly unites with the opposite electricity, which follows it from the battery. An electric wave is, therefore, as it were formed which is consumed by degrees by the following opposite one, but still moves on to the end.

In this way any number of progressive waves can be formed in the wire by rapid reversals of the battery, which set the telegraph instruments inserted at the end in motion, if they are still sufficiently strong, when they reach the end of the line.

If the currents following one another are all of the same strength and duration, then with long lines a considerable number of such waves can be made use of. But when long and short currents alternate, then the short waves are easily wiped out by those that precede and follow, either entirely, or at least so far as regards the practically useful amount.

THE SUBMARINE KEY.

The submarine key is employed to forward messages. The key hitherto used, which is shown diagrammatically in Fig. 76, consisted of a small lever D movable around 1, which was usually pressed by means of a spring against the contact 2, the position of rest. In this position the line L was in connection with the relay G, and the earth E.

But if the lever D was pressed down the connection with the relay was broken in the first place, and then by means of the contact 3, the working contact, the battery K was inserted in place of the relay.

A short pressure of the key gave a dot at the other station, a

longer one on the contrary a dash. The signals were consequently composed of dots and dashes.

If, however, underground lines are used, then on the insertion of the battery the cable is charged at the same time.

If therefore after the key was previously pressed down connection is again made with 2, the discharge current must take its way through the relay, which is quite incompatible with the

Fig. 76.

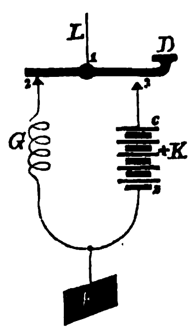
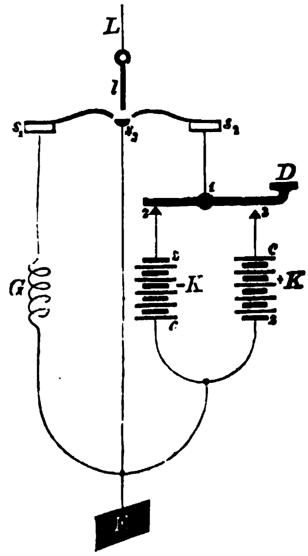


Fig. 77.



certain regular action of the relay as well as with the principle of translation.

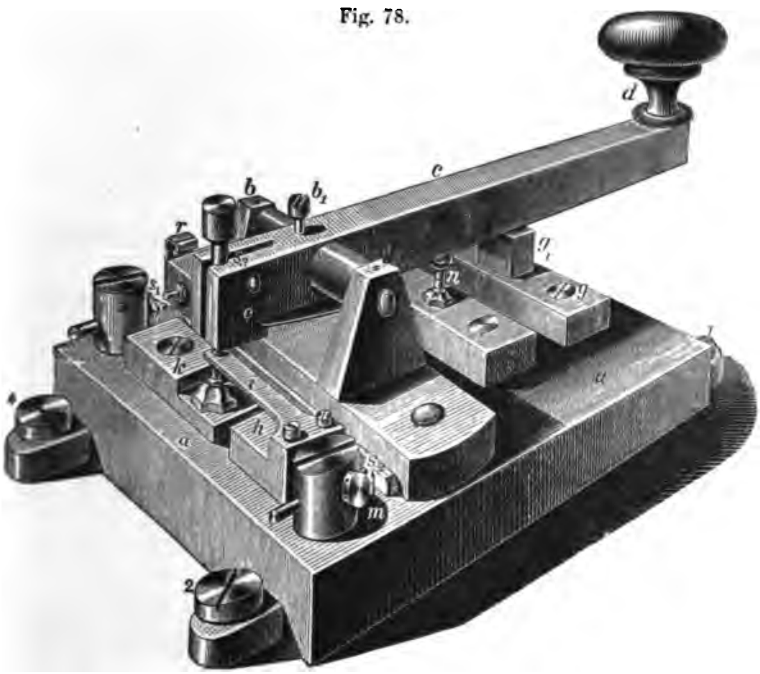
The conditions fulfilled by the submarine key constructed by Siemens and Halske are to be seen from the diagram of Fig. 77. If the line L is in contact with the point s_1, the relay G is inserted for the reception of messages; if on the contrary the line is in contact with the point s_2, the key D is inserted for the despatch of messages, and the relay is quite protected from discharge currents. If in this position the key is depressed on to contact 3, a positive current passes into the line from the battery (+K)—the working battery—if on the contrary the key rests

on contact 2, a negative current passes into the line from the battery (- K)—the opposed battery.

The arrangement therefore is the same as already explained in Fig. 76, with the additional advantage, that for the despatch of messages not only galvanic currents of opposite direction, but also at the same time discharging currents of the same direction are used.

In order, however, that the last discharge on finally restoring

Fig. 78.



the connection with s_1, may not be sent through the relay G, on the way to s_1, connection is first made with the contact s_3, which is in connection with earth, and in this way the charge is led off direct to the earth.

It was previously mentioned, that with long submarine cables, the dots before or after dashes, and especially the dots between two dashes often did not appear. Hence the necessity arose, in this case to make dots so placed longer than usual with overhead

lines, in which case one is in the position to speak through long submarine cables, at double the speed previously possible. Fig. 78 gives a perspective view of the key seen from the front. The bearings *bb*, in which the key *c* lies, can be turned horizontally about the axis b_1; it is permanently connected with the terminal 1, which is intended to take the leading wire, and with the spring *i* lying in front, and besides, in its position of rest, the body of the key is pressed against the contact s_1 by means of a spring. This contact s_1 is, however, in conductive connection with terminal 4, and this again with the relay and earth. Under these circumstances the connections are exactly the same as when in Fig. 77 the conductor is brought into contact with the point s_1. If in this position of rest it were desired to press down the knob of the key this would not be possible, as the lever C is exactly over a small stop g_1 placed on the plate *g*.

In this position of the key therefore the relay is in circuit, and the apparatus fitted for receiving messages from without.

If, on the contrary, messages are to be despatched, the arm *c* has first to be pressed to the left; by this—

1. The contact at s_1 is interrupted, *i.e.*, the relay is put out of circuit.

2. Two insulated knobs fixed on the body of the key press the spring s_2, which rests on the plate *k*, against the contact *m*; this contact *m* is, however, in connection with the terminal 2, and this again with the opposed battery (− K) and earth.

Therefore by turning the key to the left, the relay is cut out, and the opposed battery put in circuit.

But if now the key is pressed down it leaves the upper contact, and comes on to the bottom contact *n*, *i.e.*, the opposed battery (− K) is interrupted, and the working battery (+ K) closed.

The case is therefore the same, as though in diagram 77 line L were connected with the point s_2, and the key D were then pressed down.

But in order lastly after releasing the key to discharge also the conducting wire, on its recoil from contact s_1 a point on the key strikes against a spring s_3, which is in conductive connection with the earth through the terminal 5 not shown in the figure.*

* Compare diagram of the key in fig. 89, p. 174.

The play of the spring *i*, and its relation to the front contact is specially shown in Fig. 78.

As a rule in working with this submarine key it is to be observed:

1. That one must never stand immediately in front of the key, but always sideways about 2 feet to the left, for in this position the telegraphist naturally draws the lever of the key to the left, therefore the finger is not easily fatigued by the pressure of the spring;

2. that the key must be securely pressed up, so that the opposed battery may safely work, and

3. that this upward pressure must not be forgotten, when it is finally required to release the key at the completion of the work in order to receive messages from the other station.

4. Alterations in the play of the key are to be altogether avoided, as an interruption of the relay may easily arise therefrom.

THE POLARIZED RELAY.

The relay is a very sensitive auxiliary instrument for the writing apparatus. If it were desired to insert the latter directly in the circuit in order to receive messages, with very long lines too weak a current would arrive to set the apparatus at work. It is otherwise with the relay; its electro-magnet is so sensitive that extraordinarily weak currents are able to attract its armature.

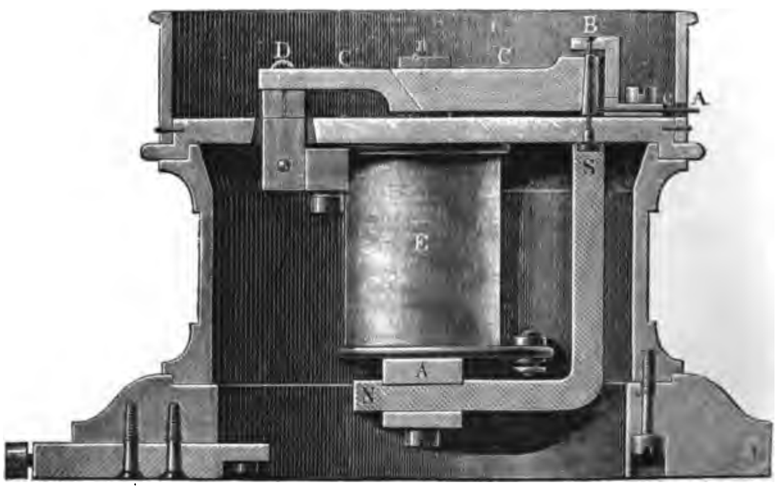
But if this happens, a local circuit is thereby immediately closed, in which then by means of a powerful local battery, the inserted writing apparatus can easily be set in action.

The relay constructed by Siemens and Halske differs very materially from those hitherto used. Fig. 79 shows the instrument in section, Fig. 80 a plan of it seen from above.

The vertical electro-magnet has two limbs joined as usual by means of the connecting armature A. The windings of those electro-magnets end in the terminals 1 and 2. The steel magnet NS bent upwards is screwed to the connecting armature. N is its north pole. The steel magnet gives both the connecting armature A, as well as both legs and poles of the electro-magnet E, a northern polarity; on the south pole S of the steel magnet, underneath the bearing B, the iron tongue C, which

must consequently also have south polarity, is so arranged that it can readily move between the two north poles *n*, *n*, of the electro-magnet. This motion is limited by the screw points D and D_1; if the screw D is turned from right to left, the space for the play is greater, if in the opposite direction smaller. The screw D serves as a contact screw; if the tongue C strikes against

Fig. 79.



it, the local circuit is thereby closed, in which are the writing apparatus and local battery.

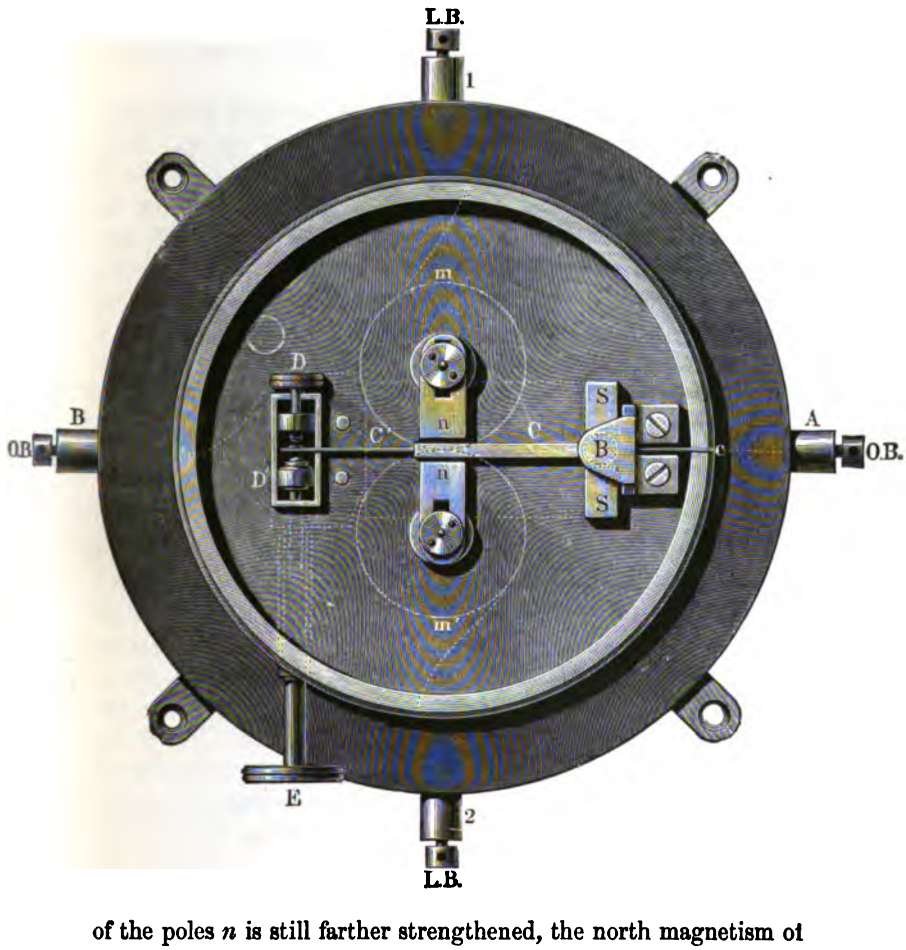
The screw D_1 has a stone point, if the tongue C lies against this, the local circuit is interrupted.

A and B are the terminals of the latter circuit. It follows from what has been said that the south magnetic tongue C cannot be attracted by either of the north magnetic poles *n n* of the electro-magnet when it lies exactly between the two; if it does not do this, however, it is always attracted by the nearest lying pole.

As above described, for the despatch of a message galvanic currents of an opposite direction are used. If the key is assumed in the first place to be depressed, a positive current passes through the conductor and the relay. This positive current considered in itself has the tendency to make one of the poles *n n* north magnetic and

the other south magnetic. But as both poles were already previously north magnetic through the action of the steel magnet N S, then by the additional galvanic action the north magnetism of one

Fig. 80.



of the poles n is still farther strengthened, the north magnetism of the other on the contrary weakened, and on this account the first pole n will more powerfully attract the tongue C. The tongue C therefore will be drawn to the contact D and remain there as long as the key is pressed down.

But if by raising the key the oppositely directed current of the opposed battery is sent through the electro-magnet of the relays the conditions are reversed, then the other pole *n* is preponderatingly north magnetic, and now attracts the south magnetic tongue C against the contact stone D_1, until the key is again depressed.

If it is desired to work without an opposed battery, then the tongue C must rest on the insulating contact D_1, when the key is not pressed down.

One pole of the electro-magnet therefore takes the place, which in the former relay was taken by the pulling-off spring. When with strong currents the pulling-off spring would have had to be strongly stretched, in this case the tongue C is placed nearer this pole, when with weak currents the pulling-off spring would have had to be slightly stretched, the tongue has to be removed farther off. The screw E serves for this purpose, being turned in the first case from left to right, and in the latter case from right to left. The backward prolongation C of the tongue only serves for moving the latter by hand, which is of practical importance for the control and regulation of the relay.

THE COMMUTATOR.

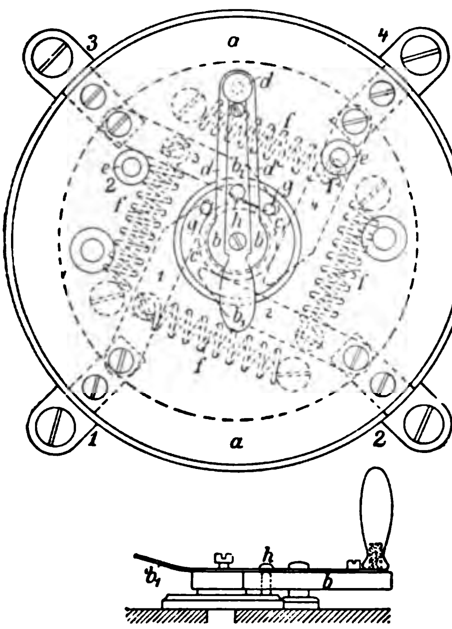
Should the galvanic current circulate round the relay in the opposite direction to what was assumed above as the correct direction, then if only one battery is used that pole *n* which in the position of rest already preponderatingly attracted the tongue would only attract this all the more; an endeavour to move the tongue to the other pole *n*, would therefore not be possible notwithstanding the action of the current in this case. But if two batteries are used, then on depressing the key the tongue would move against the insulating contact, and on releasing against the working contact, one would therefore get writing where spaces should be.

In one case one obtains thereby hardly any, in the other case however so-called inverted writing.

To obviate such contingencies, a commutator (Gyrotrope) is placed before the relay, by the help of which, by turning a handle, the current can be so directed that a correct attraction of the tongue must instantly take place.

The commutator is shown in Fig. 81 in plan and side view. Above the base a there is only seen the lever d with the handle at the end, and on the latter the steel spring b_1—e e are two stops for limiting the motion of the handle; they are distinguished by 1 and 2. When the handle comes against these stops the peg h catches in the hole g and thus holds the handle fast. If it is desired later to bring the handle against the other stop, the

Fig. 81.



spring b_1 must first be raised, by which the peg h is raised out of the hole g.

The commutator arrangement lies under the base a. It consists of 4 contact pieces 1–4, each two of which are pressed against the metal rings c_1, c by means of springs f f.

The two metallic rings are fixed on an ebonite disc b, which is therefore insulating, and which is moved together with the two metal rings by the handle d placed above the base.

Assuming the relay to be connected up between the terminals 2

and 3 the line to terminal 1 and the earth to terminal 4, then in position 2 the metal ring c_1 would connect the terminals 3 and 4, c the terminals 1 and 2, therefore the arriving current would take the course (Fig. 82).

$$L . 1 . C . 2 . (1 . R . 2 .) 3 . C_1 . 4 . E.$$

In position 1 on the other hand, the metal ring c will connect the terminals 3 and 1 and C_1 the terminals 2 and 4, and therefore the arriving current will take the course (Fig. 83).

$$L . 1 . C . 3 (2 . R . 1) . 2 . C_1 . 4 . E.$$

In the first case, therefore, the current would enter the relay on

Fig. 82.

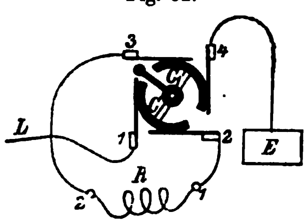
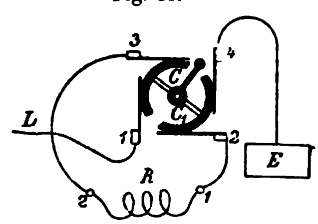


Fig. 83.



the right by 1, and in the latter case on the left by 2, which is what was aimed at.

The commutator described, differs however from those generally used very advantageously, because during the reversal no appreciable interruption of the line can take place.

THE WRITING APPARATUS.

The writing apparatus must before all things make the signals sent by the key legible at the other station; it must also during translation take the place of the submarine key, and finally must itself set in motion the clockwork necessary for moving the paper strips and stop it again.

The so-called polarized inker manufactured by Siemens and Halske fulfils all these requirements, it consists of the following principal parts:—the clockwork, the printing magnets, and the automatic release with commutator.

Fig. 84.

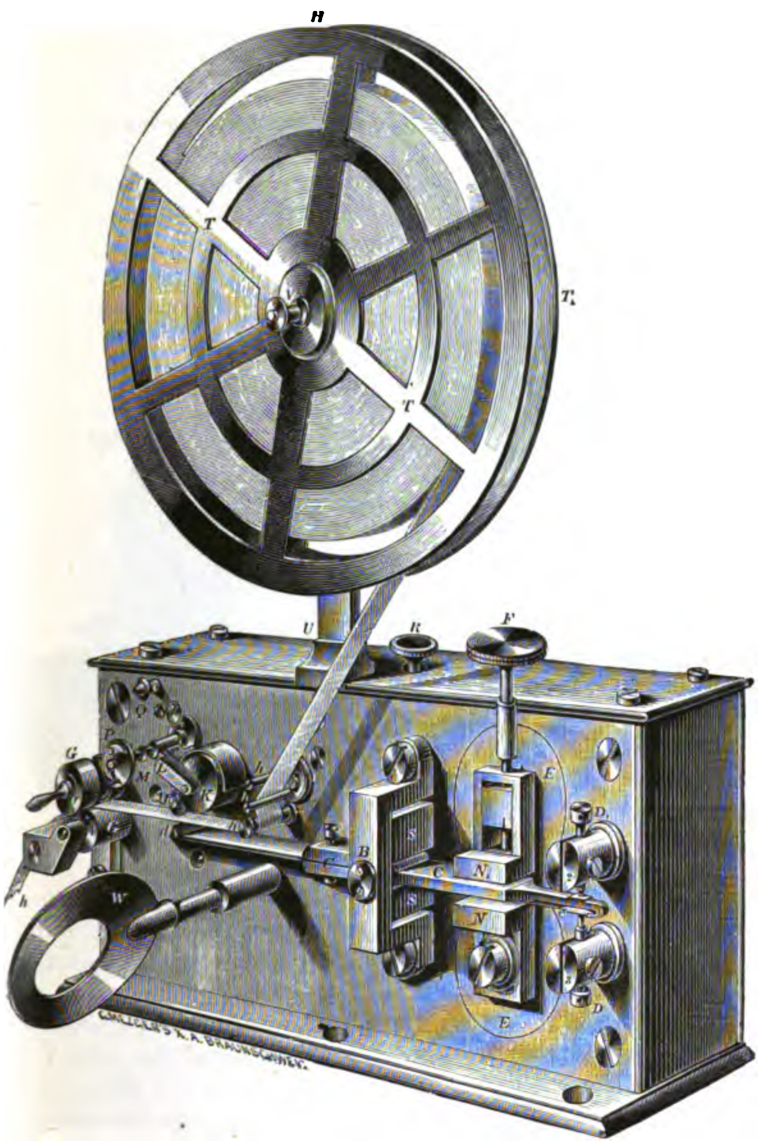


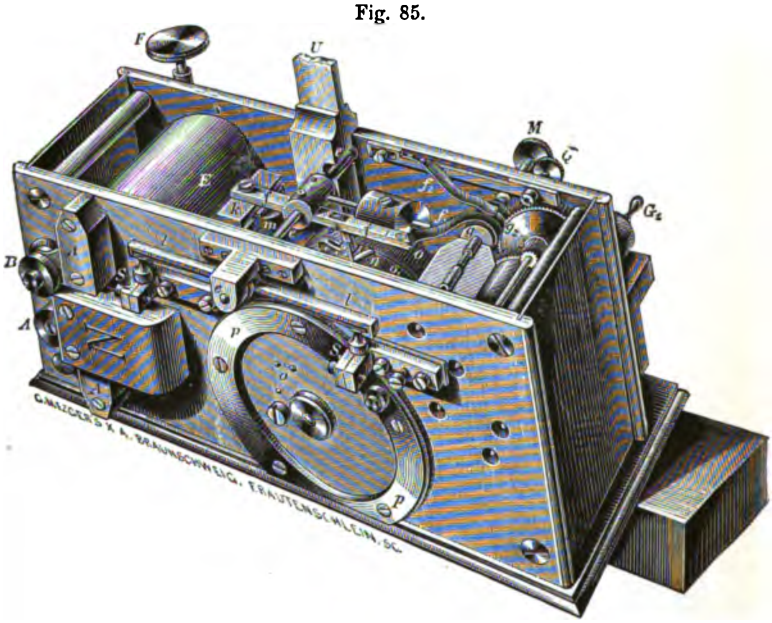
Fig. 84 shows the front of this apparatus, and Fig. 85 the back view but more from above.

THE CLOCKWORK.

The clockwork is placed inside the apparatus. Only a portion is to be seen in Fig. 85.

The object of the clockwork is to impart rotary motion to the

Fig. 85.



friction rollers G and the inking disc J. If the roller G revolves, the roller G_1 which is pressed against it by a spring is made to revolve with it, and a paper strip *h* laid between the two rollers is gradually drawn through.

On the inking disc J lies the roller K, easily movable around its axis. The claw-shaped bearing L of this axle grips the screw M; the latter finally is pushed over an axle fixed to the side of the apparatus. When now the inking disc J turns, the ink roller K which presses with its weight on the inking disc turns in conse-

quence, and so moistens the edge of the ink disc with ink. The ink roller is movable by turning the screw M, so as to bring the hitherto unused part of the circumference into contact with the ink disc.

The ink roller can be removed from its axis, as soon as the little slider P, lying on the head of the screw M, is pushed out.

The clockwork itself does not differ in other things materially from the works hitherto used. The drum *o* (Fig. 85) is turned by means of a strong internal spring, in consequence of which a combination of wheels and pinions, and finally also the rollers G and J are set in rotary motion. In order that the clockwork may go regularly, a fly-wheel is provided; if it is to stand still, the slider is pushed to the right by which the spring f_2 presses on the little ivory roller g_2 and thereby stops the clockwork.

When the clockwork has to be wound up, the winding-up key is turned to the left.

THE PAPER GUIDE.

The paper guide can be plainly seen from Fig. 84. The paper roller T turns on an axle V fixed to the pillar U. The paper lies between the two sides T and T_1 of the roller. The end of the paper passes first between the pins *h h h*, then between the printing spring *d* and the ink disc, and finally after the friction roller G is raised, is also led between the two friction rollers.

If new paper has to be inserted, the side piece T of the paper roller is unscrewed by turning to the left, the new roll of paper is laid in, and then the side piece is carefully screwed on again.

THE PRINTING MAGNET.

The printing magnet is constructed in the same way as that of the relay. The legs E E of the electro-magnet are in this case horizontal. In Fig. 85, the armature A and the north pole N of the steel magnet are to be seen, in Fig. 84 the bent up south pole S of the steel magnet. Here also are to be seen the two poles N, N_1, of the electro-magnets which become north magnetic by induction.

The printing lever C moves between these poles about the axis B, the contact screws D and D_1, limit this motion. On the

other side the printing spring *d* is fixed to the printing lever. The pole N_1 of the electro-magnet here takes also the place of the pulling off spring; for strong currents it stands nearer to the printing lever than for weak. The adjustment necessary for this purpose is effected by means of the screw F, accordingly as it is turned to the right or left. If a galvanic current passes through the windings of the printing magnet, then the attractive force of the pole N is strengthened, that of the pole N_1, weakened, the printing lever therefore moves towards the pole N, the printing spring *d* rises, and presses the paper strip *b* lying above it, against the ink disc J moistened with printer's ink.

If the latter moves after the starting of the clockwork, a dot or dash appears upon the paper strip, accordingly as the printing spring presses for a shorter or longer time against the ink disc, in consequence of the action of the galvanic current.

The mechanism of printing has only come into greater use in recent times. Already in the year 1854 there was working in the central station at Vienna, apparatus with ink printing according to the designs of John, assistant engineer at that place. The process there applied is copied in its essentials in the above-described apparatus.

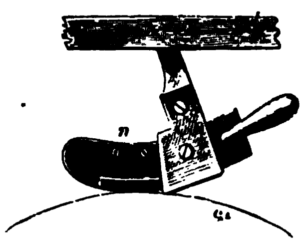
THE AUTOMATIC RELEASE.

The mechanism of the automatic release has for object the starting of the clockwork without the use of the slider knob Q at the beginning of a message, and the stopping it on its completion. Fig. 85 shows the details in perspective.

Close up to the printing magnets there is placed a second small electro-magnet *m*, the releasing magnet, which is in the same circuit as the first; one and the same galvanic current therefore suffices to energize both electro-magnets. The armature *k* of the releasing magnet is fixed to the releasing lever *f*, which turns on the axis *e*. At the other end of the releasing lever is placed the friction spring f_1, which in the position of rest—*i.e.*, when the armature *k* is not attracted—presses on the little ivory roller *g* lying under it, and so stops the clockwork, in the same way as if the spring f_2 were to be pressed by sliding knob Q on the ivory roller g_2. The pressure of the spring f_1 is regulated by a weight.

Assuming that the armature k is attracted, the spring f_1 rises from the wheel g, and the clockwork starts; at the same time, however, the shoe n, which lies to the side of the pressing weight, and is shown in detail in Fig. 86, assumes a perpendicular position, so that the heel dances on the rotating drum lying below it so long as the message continues. But if the latter ceases the shoe in consequence of friction is again moved sideways along with the drum; in consequence of this the friction spring f_1 falls again on to the roller g, and the clockwork is stopped. If the knob Q projecting from the upper plate shown in Fig. 84 is pressed, the armature k is thereby pressed down, and the clockwork also released.

Fig. 86.



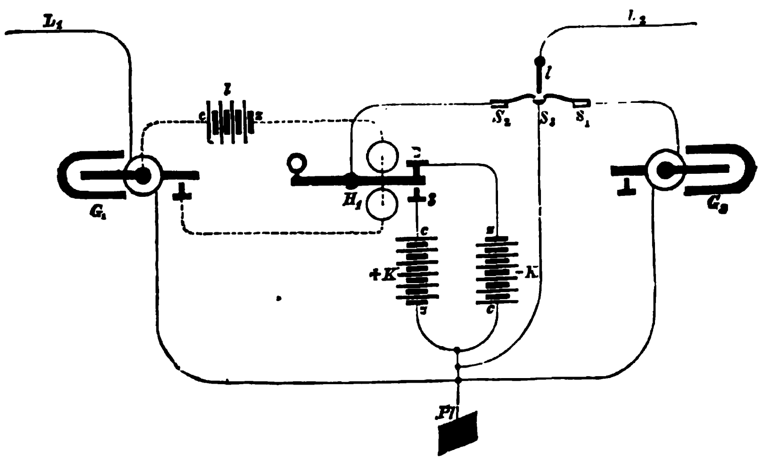
THE TRANSLATION; THE WRITING APPARATUS AS SUBMARINE KEY.

If we assume the case, that a message is not only to be sent to the nearest station but also to several further stations then at all the intermediate stations the second apparatus would have to give out again the message received by the first apparatus, *i.e.*, the key of the second apparatus would have to be depressed by the telegraphist just as often and as long, as the printing lever of the receiving apparatus is attracted by the current. Hence the printing apparatus can also be employed for the translation of messages as soon as it is connected up in place of the key in the continuation of the line, and is so arranged that it fulfils altogether the conditions of the submarine key shown in Fig. 77.

Fig. 87 shows this diagram transferred to the writing levers. L_1 and L_2 are the incoming and outgoing lines. If the

relay G_1 of the receiving apparatus is brought into use, the local battery I is also closed and the printing apparatus H_1 attracted, whilst the printing lever moves from stop 2 to stop 3. To the first stop the opposed battery is connected up, to the second the working battery. If now the printing lever is connected with the outgoing line L_2 by putting the handle l on s_2, then when the printing lever H_1 lies against the stop 2, a negative current circulates in the line L_2 in the direction $(-K)$, Pl, earth, opposite apparatus, L_2, l, s_2, H_1 $(-K)$, but if the printing lever H_1 is attracted to the stop 3, a positive current circulates in the line L_2 in the direction $(+K)$, 3, H_1, s_2, l, L_2, opposite apparatus, earth, Pl $(+K)$.

Fig. 87.



Hence the printing apparatus will automatically send all signals that it receives to the apparatus at the next station.

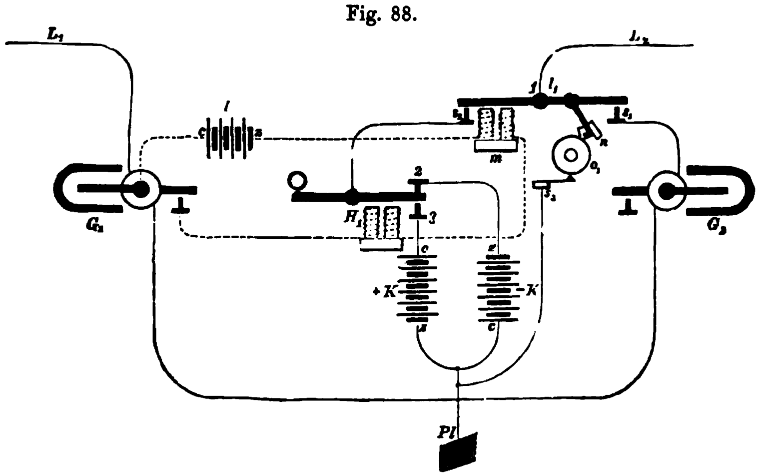
As moreover the line is not in contact with the point s_1, the discharges are not able to pass through the relay. Suppose, however, that the relay is again inserted for the receipt of a message by moving the handle from s_2 to s_1, the handle l strikes the earth contact s_3 on its way, and the line is thereby discharged, before it has come into contact with the relay.

In Fig. 87 it was only shown diagrammatically, what conditions the printing apparatus had to fulfil as a submarine key.

Actually the switching over by hand by means of the lever *l* could scarcely be done in time and with sufficient certainty.

With the printing apparatus manufactured by Siemens and Halske, therefore, this is effected by the apparatus itself without the assistance of the operator. At the back of the apparatus there moves on the axis *e*, besides the releasing lever *f*, lying on the inside, the commutator lever *l* (Fig. 85). In the position of rest this lever lies on the contact screw s^1, which is in connection with the relay; if the armature of the small electro-magnet *m* is attracted, the commutator lever lies on the contact screw s_2,

Fig. 88.



which is conductively connected with the printing lever. The lever arm *l* effects therefore the positions s_1 and s_2 of the handle *l* in the diagram Fig. 87, but not the position s_3 for the discharge of the line; this latter is brought about by the shoe piece *n*.

The shoe piece is insulated in front at the toe and at the heel, but not in the middle of the sole; therefore in the position of rest or motion no conductive connection takes place between the shoe piece, *i.e.*, the lever *f* and the drum *o*. But as soon after the conclusion of the message as the shoe piece slides sideways, then the conducting portion of the shoe, cross hatched in Fig. 86, comes into connection with the insulated platinum ring o_1 of the drum and through the spring s_3, also with the earth. Only later,

after the insulating toe of the shoe lies on the drum, is the connection of the lever l finally made with the screw s_1, *i.e.*, with the relay.

In this case the diagram would stand as in Fig. 88.

In the position of rest the direction of the current would be the following :—

$$L_2,\ l_1,\ s_1,\ G_2,\ \text{Pl, earth, opposite station, } L_2.$$

The relay is therefore in circuit. But if the writing apparatus H_1, and therefore also the releasing magnet m is attracted by the line L_1, the latter will throw the lever l_1 against the contact s_2 and at the same time interrupt the relay circuit at s_1, then the following is the direction of the current $(+K)$, 3, printing lever H_1, s_2, l_1 L_2, opposite apparatus, earth, Pl $(+K)_1$, and when the printing lever touches contact 2 the direction is : $(-K)$, Pl, earth, opposite station, L_2, l_1, s_2, printing lever H , 2 $(-K)$.

If, finally, the conducting sole of the shoe lies on the platinum ring o, of the drum, then the connection is

$$L_2,\ n,\ o_1,\ s_3,\ \text{Pl, earth.}$$

THE TRANSLATING SPRING.

From what has been said it follows that with translation, the closing of the working and opposed batteries, or the so-called line batteries is effected by the printing lever, and that, when any number of intermediate stations join themselves up for translation, a message can be sent throughout without the assistance of the operator. But a difficulty that occurs has not yet been considered. When the printing lever, in consequence of the action of the current, passes from the upper stop 2 to the lower 3, a certain time is, however, lost as regards the actual attraction of the armature, and therefore also as regards the length of the signals on the paper. The printing lever will, therefore, remain down a shorter time than the key was pressed down at the sending station. But this is repeated at each consecutive station, so that finally when many translations take place the original signals must be sent very slowly, so that at the last station signals may appear which are at all legible.

This disadvantage is fully overcome in the translating spring *c* (Fig. 84) designed by Siemens and Halske, which lies below the printing lever, directly over the stop 3 ; as soon as the printing lever sinks somewhat on being attracted, this spring already touches the contact 3, later on if the printing lever rises again, the spring remains nevertheless for a certain time stationary and leaves the contact only at the last moment.

By the use of this spring the telegraphist therefore need not take any notice of the time of the attraction, the same length of signal which was had in view at the place of despatch will distinctly appear at the arrival station, if charging phenomena do not produce any modifying effect.

THE MUTUAL CONNECTION OF THE PARTS OF THE APPARATUS AND BATTERIES AND THEIR ACTION.

Whilst in what has preceded all the parts of the telegraphic appliances have been separately described with respect to construction and use it yet remains to make clear the connection of all the parts as a whole and to explain their working in this combination.

The principles kept in view were :—

(a) The greatest possible simplicity and facility for inspection in the arrangement.

(b) Perfect similarity of all apparatus and connections.

(c) Special selection and work as regards unusual transport and climatic influences.

(d) Simple service and safe performance of the apparatus, having regard to particular exigencies.

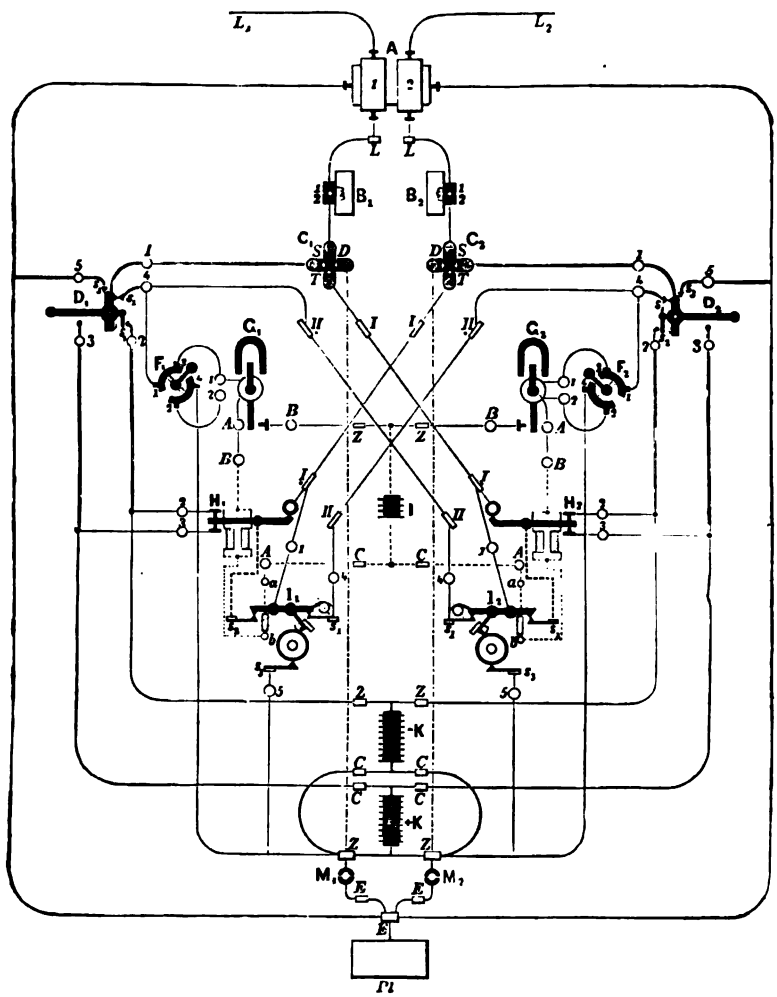
(e) Manifold application of the apparatus, so that at intermediate stations each apparatus can be joined up to the line as end, translating or simple intermediate apparatus.

In accordance with the above requirements, the parts of the submarine apparatus are fixed not on a wooden but on a slate base, and besides wherever practicable wood and iron are carefully avoided.

To make the apparatus easy of installation even by an unskilled person all the connections are already fully arranged under the slate base, and besides the usual weight for the printing apparatus

is replaced by a spring. The terminals of all apparatus are marked, those terminals lying in the local circuit with consecu-

Fig. 89.



tive letters, those in the line circuit with consecutive Arabic figures.

THE COURSE OF THE CURRENT.

In order to be able to follow easily and surely the direction of the current and the resulting actions for the different ways of connection, all the parts and connections are diagrammatically brought together in Fig. 89.

In this

A is the lightning discharger.
B the galvanoscope.
C the translation commutator.
D the submarine key.
F the current commutator.
G the relay.
H the printing apparatus.
M the interrupter.

The terminals on the apparatus are represented by circles, those on the base by rectangles. Moreover all connections belonging to the translation are shown by unbroken lines, and all for the local circuit by dotted lines, whilst by double lines and broken lines formed of strokes and dots the remaining connections for the terminal connection and for cutting out the apparatus are shown.

After these preliminary remarks some of the most important paths of the current may be more closely considered.

The apparatus connected up as terminal apparatus.

Both translation commutators stand at *s*.
Both current commutators stand at 1.
Both interrupters are stoppered.

A.—Apparatus 1 *Receives Messages.*

The current sent from the opposite station by means of the submarine key traverses the line L^1, goes through the plate 1 of the lightning discharger A to the L terminal of the apparatus, to the galvanoscope (1, B_1, 2) to the translation commutator C_1, through the stoppered S plate to the key (1, D_1, 4) to the current commutator (1, F_1, 3) to the relay (1, G_1, 2), again to the current

commutator (2, F_1, 4), to the Z terminal, to the stoppered interruptor M_1, to the E terminal, to the earth plate Pl in the earth, and through the same to the battery of the opposite station.

In consequence of this the tongue of the relay G_1 is thrown against the metal contact, and the local circuit closed thereby as follows.

Local battery (Z, I, C), to the printing apparatus A, *a*, windings of the releasing magnets *b*, at the same time round the windings of both legs of the printing magnet B, to the body of the relay (A, tongue metal contact B) back to Z of the local battery.

In consequence of this, as already described, both magnets of the printing apparatus are attracted; the releasing magnet sets the clockwork free, and the printing lever is attracted, until a current in the opposite direction from L_1, again draws away the tongue of the relay from the metal contact.

B.—The Apparatus 1 *Sends a Message.*

The key D_1 is pressed sideways, so that the spring s_2 lies against the contact 2. Then the opposed battery $-K$ is closed in the following way:

(Z, $-$ K, C), Z, M_1, E, Pl, earth, relay of the opposite apparatus, L_1, to the lightning discharger A, (1, B_1, 2), (C_1, S), (1, D_1, s_2, 2) back to the battery $-K$.

A negative current therefore circulates through the line and through the relay of the opposite apparatus, the tongue of which is therefore held tight against the insulated contact.

But if the key D_1, is now pressed down the connection with the spring s_2 is broken and instead the key lever is connected with the contact 3, whereby the working battery $+K$ is closed in the way (Z, $+$K, C), (3, D_1, 1), (S, C_1), (2, B_1, 1), L, A, L_1, to the relay of the opposite apparatus, to the earth Pl, E, M_1, Z, and back to the working battery $+K$. A positive current therefore traverses the line and the relay of the apparatus, its tongue therefore is thrown against the metal contact as long as the key is pressed down.

The printing apparatus works accordingly just as before described.

If the key now returns to the position of rest the above described discharge through the contact s_2 finally takes place.

The Apparatus I. and II. Translate.

Both the translation switches on T.
Both current commutators on 1.
Both interrupters are stoppered.
The apparatus start automatically.

The positive current from the opposite station takes the direction L_1, A, L, (1, B_1, 2), (C_1, T), I. to the apparatus II., there I., printing apparatus H_2, there (1, l_2, s_1, 4), II., II., back to apparatus I., there II., 4, (1, F, 3), (1, G_1, 2), (2, F_1, 4)$_1$, Z, M_1, E, Pl, earth back to the battery of the opposite apparatus.

It follows:—

1. Thereby G_1 will close the local circuit exactly as above described, and hence

2. Both magnets of the printing apparatus H_1 are attracted, the releasing magnet is released, the printing apparatus prints the signal.

3. If the printing lever touches contact 3 the battery $+K$ is closed through the line L_2 so that it takes the direction (Z, $+K$, C), (3, H_1, s_2, l_1, 1), I., to apparatus II., there I. (T, C_2), (2, B_2, 1), L, A, L_2, opposite station, back through the earth, Pl, E, M_1, back to the battery $+K$;

4. But if the printing lever touches contact 2, then quite analogously the battery $-K$ is closed through the line L_2 in the direction (Z, $-K$, C), Z, M_1, E, Pl, earth, to the opposite apparatus, through line L_2, back to A, apparatus II, L, (1, B_2, 2), (C_2 T), I; to the apparatus I,—there I., (1, l_1, s_2, H_1, 2), back to the Z of the battery $-K$.

Therefore, by means of the printing lever, the working and opposed batteries are closed just as they are at the sending station through the submarine key.

5. But whilst the releasing lever l brings about the contact at s_2, the earlier connection at s_1 is broken and the path from l_1 to the relay G_2 for the discharge currents of the batteries $-K$ and $+K$ is interrupted.

6. When the translation is finished, or when the releasing lever is no longer attracted, the shoe piece glides sideways on the drum, makes earth, and so discharges the line. Finally the clockwork is

stopped by the end of the releasing lever pressing on the friction disc of the fly-wheel axis.

If the speaking is in the opposite direction the apparatus work in the same manner.

SIEMENS AND HALSKE'S SINE-TANGENT GALVANOMETER.*

Fig. 90 gives a perspective view of an instrument for galvanic measurement by angles, which can be used both as a sine and tangent galvanometer. The circular plate P on which are rigidly fixed the wire coil R, and the needle-box M, can be turned by two insulated handles, of which only one is to be seen in the figure, in the plate Q provided with a cone. On Q there is a graduated circle and on P the index corresponding to it. By means of this graduated circle the angles are read in the usual way, when the galvanometer is used as a sine galvanometer. In the needle-box there is also a graduated circle by which the angles are read, when the current is to be measured by the tangent of the angle of deflection. The wire coil R consists of about 16 windings of thick wire, $1{\cdot}39^{\mathrm{mm}}$ in diameter, which connects the terminals K_1 and K_2, and of about 1050 windings of thin wire of $0{\cdot}25^{\mathrm{mm}}$ diameter, which connects the terminals K_3 and K_4. The thick windings have a total resistance of less than 0·1 Siemens' unit, whilst the thin windings have a resistance of about 150 Siemens' units. If the terminals K_1 and K_2 are connected to the poles of a battery, the thick wire is alone in circuit, and in the same way the thin wire is in circuit when K_3 and K_4 are connected to the poles of a battery.

By drawing up the knob *a* two pegs in the needle-box are pushed up, so that the needle swings within narrow limits.

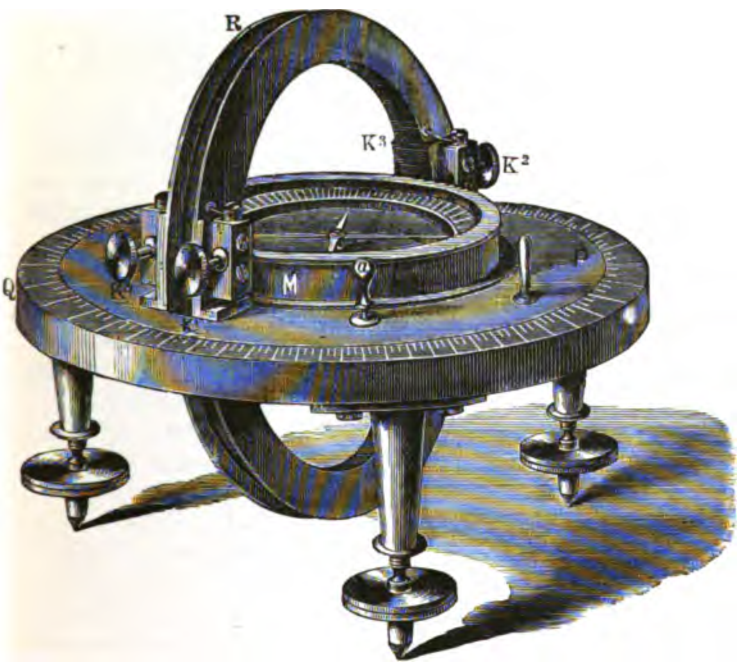
Accordingly as the instrument is to be used as a sine or tangent galvanometer, a long or a short magnetic needle is inserted, both

* From a communication by W. Meyer to the Journal of the Deutsch-Oesterr. Telegr. Vereins, Vol. VII. p. 106. 1859.

needles are provided with aluminium pointers, which reach to the inner graduated circles.

If the currents to be measured are so strong, that the reading of the angle is impossible, then only a portion of it is allowed to pass through the instrument, by inserting a second resistance

Fig. 90.



between the respective terminals of the instrument, bearing a certain proportion to the resistance of the instrument.

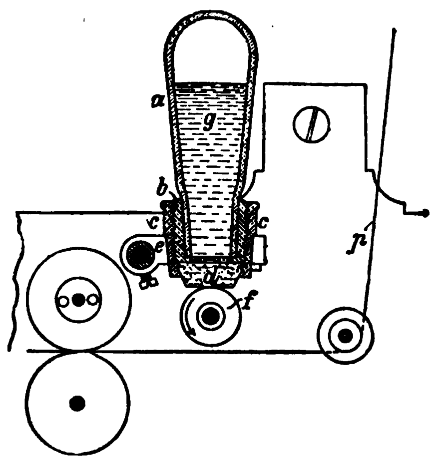
This combined sine and tangent galvanometer is also specially applicable for telegraphic purposes. All the measurements in laying the cable in the Red Sea were made with it; these instruments were also used for the current angle measurements on the line.

PATENT SPECIFICATION OF A NEW INKING ARRANGEMENT FOR PRINTING TELEGRAPHS WITH PRINTER'S INK.*

In the so-called inkers hitherto used the ink disc is covered with printer's ink, by passing a roller over the latter, covered with felt or similar material and saturated with ink. In place of this ink roller we have constructed the ink bottle represented in the drawing.

The capsule *b* provided with a screw thread and having a hole

Fig. 91.



below is fastened with cement to the glass *a* (Fig. 91), and on this the ring *c* is screwed, the lower opening of which is closed by a filter of felt, cloth, &c. The ink bottle so arranged is fixed on to the arm *e*, and then rests on the ink disc *f*. If, therefore, the latter is set in rotation by means of the clock work, and if thin ink is placed in the glass *a*, then the ink disc *f* is moistened by means of the damp partition wall *d*.

The advantages of our ink feeder over the ink roller formerly

* 28th November, 1860.

used consist according to the results of a long series of experiments in the following :—

1. The colour cannot dry up or get covered with dust, as was the case with the free-lying roller.

2. The colour must therefore always remain thin, which could not possibly be attained with the ink roller.

3. The telegraphist need not take care that the proper quantity of colour is supplied, that is now regulated of itself.

4. For the same reason the ink disc *f* is always evenly moistened.

5. And hence the printing is always even. It no longer happens, that from want of colour it becomes pale and interrupted, and from a superfluity of colour blotted, and therefore equally indistinct.

6. The writing dries instantly, so that blotting in consequence of handling too soon no longer takes place.

7. Thus and by the avoidance of accessible spots covered with ink, the whole apparatus is maintained cleaner than was formerly the case.

We consider as our improvement, which to the best of our belief has not previously been used with inking apparatus, the ink feeder construction essentially as above described.

DESCRIPTION OF SIEMENS AND HALSKE'S UNIPOLAR RELAY.*

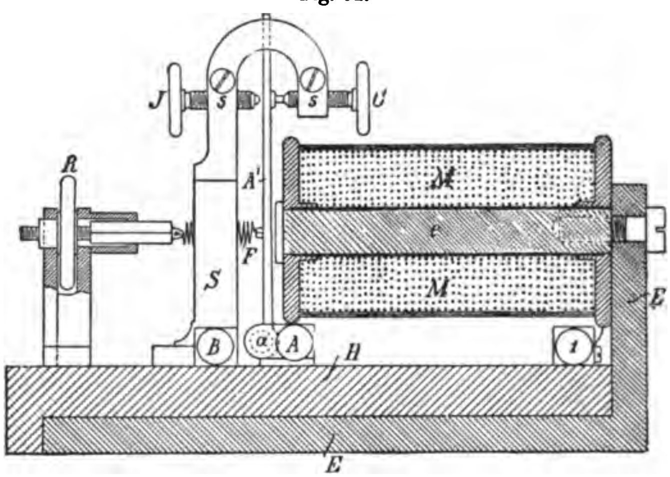
Hitherto the horse-shoe form has always been given to electro-magnets which had to work by means of weak currents through the attraction of a piece of soft iron, as for instance the magnets used for relays.

In fact one pole of a magnet of given dimensions attracts a piece of iron only slightly, the attractive force of the two poles of the electro magnet becomes therefore very considerably in-

* 1860.

creased by the horse-shoe form. On the other hand horse-shoe magnets have the great disadvantage that the attraction of the armature disappears only slowly and imperfectly after the cessation of the current. The remanent attractive force, which is a consequence of the magnetism remaining in the closed circuit of the magnet and armature brings great disadvantages with it, which are specially disturbing with relays and magnets for telegraphic purposes, in particular if the circumstances necessitate strong variation in the strength of the current used and variation in its direction.

Fig. 92.



We have succeeded in almost altogether removing this disadvantage, by using a unipolar acting instead of a horse-shoe magnet, which is nevertheless so mounted that its attractive force under otherwise similar circumstances is almost as great as that of a horse-shoe magnet which is supplied with the same number of windings. Fig. 92 represents the section of such a relay with a unipolar acting magnet.

The iron core of the magnet M consists of a slit iron tube *e* which is screwed on to a long and stout angle iron E. Opposite to the pole plate at the other end of the iron tube stands a light armature plate A^1 the lower end of which is screwed to a comparatively thick iron barrel *a*.

The barrel *a* is fixed to the base-plate H. On the same base-plate stands the pillar S, with the two screws J and C, of which the first is insulated by a stone point, and the latter is provided with a metallic point. Between these screws plays the extension of the iron plate A^1; it is drawn back by the spring F, to which any desired tension can be given by means of the nut R.

A relay so constructed is moved by nearly as weak a current as a horse-shoe relay with the same amount of wire. The reason of this phenomenon is to be sought, in that the iron mass E conducts away the free magnetism of the magnet pole fixed to it, and thus doubles the free magnetism of the other pole. The iron mass E thus acts as a reservoir as it were for the magnetism of one magnet pole. The relatively strong iron barrel acts in the same way as regards the magnetism of the armature plate A^1. Assuming that north magnetism is produced by the current in the effective magnet pole, this will magnetise the iron armature lying opposite it so that the portion lying near the polar surface is south magnetic, the distant one north magnetic. The non-magnetic space between the two magnetisms will lie near to the iron barrel *a*, the north magnetism is therefore almost entirely withdrawn from the sphere of action of the north magnetic magnet pole, and can no longer work against the attraction of the armature. By this construction therefore the same result is obtained as by the horse-shoe magnet; the attraction is therefore not observably less. When the current ceases the opposite magnetisms in the magnet and armature, which were removed from each other through the iron masses, but not destroyed as with horse-shoe magnets, come into action again, striving to expand over the whole mass of iron. The demagnetization of the magnet and armature is not only effected as with the horse-shoe magnet, by the iron molecules striving to return to their place of rest, but the neutralization is aided through the returning opposite magnetisms, by which the demagnetization takes place more quickly and perfectly. Experience shows that such a relay is nearly as sensitive as one equally favourably made as a horse-shoe magnet, and that it bears equally well each alteration of current strength, and particularly change of current, without necessitating a correction in the tension of the spring or of the distance of the armature. Instead of the iron tubes a simple bar of iron can clearly be used, or where

great sensitiveness is desired two or more pieces of iron supplied with separate windings. But these must be surrounded by currents in the same sense, so that in their total action they play their part as simple bar magnets.

SIEMENS AND HALSKE'S MORSE APPARATUS FOR USE WITH INK.*

As is known, there is this disadvantage with the Digney construction of Morse apparatus for ink writing, that the clearness of the writing is in great measure dependent on the uniformity of the laying on of the colour on the ink roller; if this has too much ink in places the writing becomes blotted, if it is kept too dry, the marks are faint and even indistinct. Owing to the paper dust, which always collects after a certain time on the ink roller, and gets united in a hard crust with the colour, this difficulty is still further increased since the freshly laid on ink can now no longer soak into the felt of the roller.

Messrs. Siemens and Halske have found occasion to use another construction of Morse apparatus for use with ink; in this the printing disc is not supplied with ink by a felt roller, but rotates with its lower part in a little bowl filled with ink placed under it, and gets the necessary ink from it, whilst simultaneously a thin plate slipping on it clears off the superfluous ink.

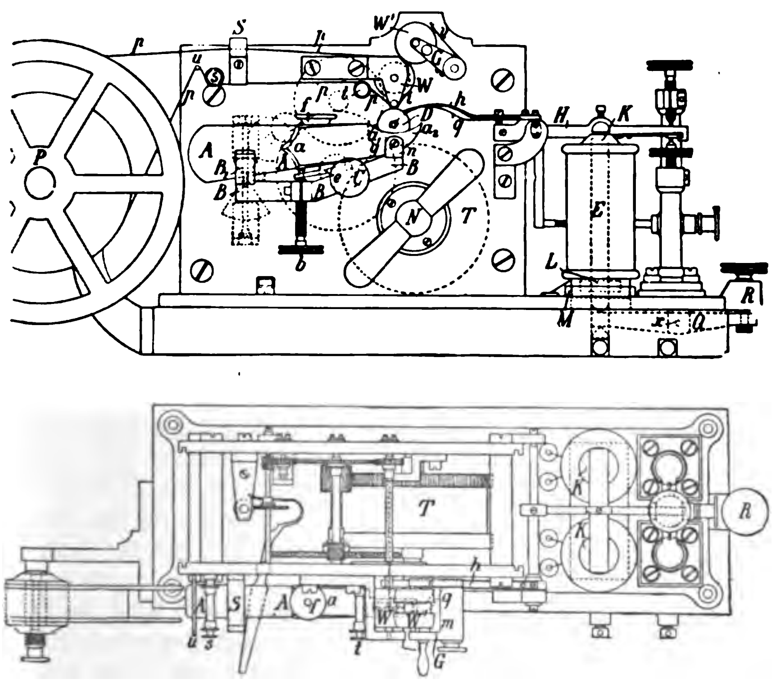
In the following figures an inker is shown constructed on this principle; Fig. 93 shows the front and top view; Fig. 94 gives a side view.

AA (Fig. 93) is a glass vessel intended for the reception of the supply of ink cemented to a metal rim a, a_1, a_2, which is fixed in an almost horizontal position in the stirrup $BBBB_1$, revolvable around the pin n. The front portion of the metal rim at a_2 is open above and cut out bow-shaped, and forms a channel shaped bowl, in which the lower portion of the printing disc dips; f is

* Journal of the Deutsch-Oesterr. Telegraphen Vereins, Vol. IX. p. 205. 1862.

an opening for pouring in the ink. With such thinly rubbed oil colours as are always used for the purpose in question, a portion always settles gradually to the bottom, and the printing disc D would then only dip into the upper layer of oil containing very little colour ; to prevent this there is inside the colour vessel, at

Fig. 93.



a_1, a partition g reaching almost to the opposite underside of the vessel, which acts so that only the lower layer of the fluid which is rich in colour can enter the little bowl a_1, a_2 ; on the other hand this also prevents the paper dust from falling into the little bowl and soiling the supply of ink in the flask. The opening at the lower end of the partition must not be too narrow, so that it may not get clogged.

The stirrup BBB_1 is fixed to the front part of the apparatus by means of a pin and a thumb-screw C, so that after loosening the

thumb-screw the stirrup with the flask can easily be taken off for the purpose of filling or cleaning the latter. The arm B_1 of the stirrup bent in front at right angles, serves simultaneously as protection and guide to the flask. There is further attached to the stirrup a set screw *b*, which serves as a second point of support for the flask, and for raising and lowering it. For this purpose a hook *e* slit like a fork and fixed to the bottom of the flask surrounds with its prongs the grooved neck at the point of this set screw.

The printing disc is as usual geared by means of a friction wheel with the clockwork so that it receives a rotatory motion from

Fig. 94.

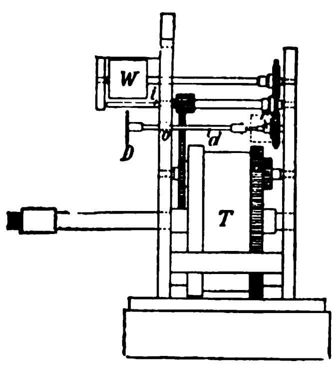
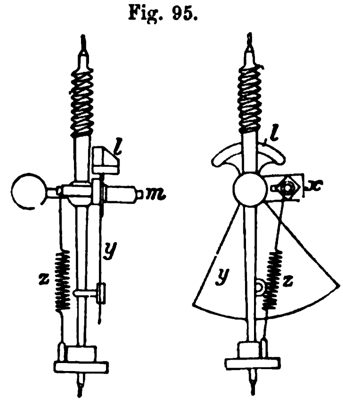


Fig. 95.



it. Its connection with the clockwork is hence not rigid, but of such a kind that it allows of a slight side motion of the little disc besides its rotatory motion. To effect this the axis of the little disc *d* (Fig. 94), provided with a sleeve at its back end, is pushed over the lengthened pivot of the corresponding driving wheel *r* and is connected with it by means of a pin; the sleeve and the pin hole in the pivot are, however, designedly made somewhat too wide so as to constitute a sort of universal joint. The front end of the axis *d*, immediately behind the little disc D, is surrounded loosely and carried by an arm fixed to the printing lever. The axle *d* has no bearing in the side of the apparatus; but on the contrary there is a large opening *o* at the corresponding place, in which the axis *d* has thoroughly free play. On the attraction of

the armature by the electro-magnets, therefore the printing lever will raise up somewhat the printing disc D by means of the arm *h* and press it against the horizontal pin *i* above it. A thin steel plate *g* crooked towards the front is fixed to the printing lever H near to the arm *h* which glides loosely on the printing disc, near its edge, and removes the superfluous colour.

The supply of paper is somewhat more complicated than usual; the course which the paper strip follows is represented by *ppp* in Fig. 93. From the roller P, the paper strip passes first over the pin *u*, then under the delivery cylinder *s* and over the similar cylinder *t* to the pin *i*; passes away again under this, by which, as often as the armature is attracted, it receives the writing signals, then rises up, and arrives between the delivery rollers W and W^1, of which the first turns in fixed bearings, and is in gear with the clockwork, whilst the other hangs in the fork G and is pressed by the spring *v* against the former. The loose roller W^1 is deeply notched in the middle and seizes the paper only near to the rims, so that the still fresh signs cannot be obliterated. From the rollers W, W^1 the paper then runs with the printed side upwards back over the rounded bridge S and then leaves the apparatus. The whole writing therefore from the rollers W, W^1 onwards lies perfectly free and uncovered before the eyes of the telegraphist. The printing dries quickly provided only a suitable colour is chosen, and only slightly sized paper is used; it comes out of this apparatus very correct and clear, and one has neither to guard against the drying of the colour nor soiling by paper dust in the same degree, as in former constructions.

The telegraph contact of the printing lever is, as with most of Siemens and Halske's apparatus, provided with a contact spring for ensuring the closing when using the apparatus for translation. The electro-magnet itself is so arranged that within certain limits it may be raised or lowered at pleasure, and its poles may thus be brought to a greater or less distance from the position of rest of the armature, without the necessity of altering at all the position of the contact screws; an arrangement by which the regulation of the apparatus is simplified to an extraordinary degree. It rests, as shown in Fig. 93, on one end of a lever Q, rotating about the axle *x*, the other end of the lever being supported by the point of the set screw R, which projects out of the base-plate of the

apparatus. The cylindrical continuations L of the core, which fit exactly in the cylindrical holes bored in the metal plates MM, thereby serve as guides to the electro-magnet.

With the apparatus shown in Figs. 93 and 94, the motion of the clockwork is not worked as usual by a weight, but by a spring enclosed in the barrel T. As this spring works with varying force, according as it is entirely wound up, or considerably run down, in the usual arrangement the paper would run out at first more quickly and afterwards more slowly, the printing signal would, therefore, be very long directly after the winding up, and afterwards very short. In order to prevent this a flywheel is arranged similar to the so-called centrifugal governor. Fig. 95 shows it in two different positions in 4-5ths of its natural size. A vertical axle is turned around its axis by the clockwork. To it is fixed the fly *y* by an axle *m*, which is exactly balanced by the weight *l*. The fly is pressed down by a spring *z*, which works on the lever arm *x*, but is raised by centrifugal force. These two forces are in equilibrium in any position of the fly for a fixed velocity of revolution dependent on the force of the spring and the weight and form of the fly. The slightest increase of velocity must, therefore, place the fly perpendicular to the axle, whilst the slightest reduction would give the preponderance to the spring and bring the fly in the position parallel to the axis. Since when the fly is raised the resistance of the air increases in rapid proportion, the regulator would maintain the speed of the clockwork quite constant if the friction of the pivots of the fly did not introduce a slight variation. Disregarding this friction, this regulator does not, therefore, work like a Watt's centrifugal governor as a moderator of the change of velocity of rotation, but maintains it quite constant, and is consequently an actual governor.

When the apparatus is driven by a uniformly acting weight, this construction of the fly is not necessary, and for such apparatus Messrs. Siemens and Halske employ the usual fly with fixed wings.

THE GREAT VOLTA INDUCTOR FOR THE SECOND LONDON INTERNATIONAL EXHIBITION, 1862.

This consists of a cylindrical core of varnished iron wire $1{\cdot}3^{mm}$ thick and 95^{cm} long, cemented together to form a cylinder 60^{mm} thick. This core of iron is wound with two windings of copper wire $2{\cdot}5^{mm}$ thick. The iron core and windings weigh 35 lbs. This bundle of iron wound with copper wire is placed in a tube of ebonite 26^{mm} thick at the ends and 12^{mm} thick in the middle. On this tube 150 thin ebonite discs are fixed at equal distances. Thick discs of the same substance form the end pieces of the space intended for the secondary coil. The single cells between the discs are wound with copper wire only $0{\cdot}14^{mm}$ thick, covered with silk and then with a suitable varnish. The wire is about 10755 metres long, which produces 299198 turns around the core of the apparatus. The weight of the copper wire amounts to 58 lbs. The resistance of the secondary wire amounts to 162000 metres of mercury of a square millimetre section, at zero temperature. The primary coil consists of two windings, each of 0·32 mercury unit resistance, which can either be joined in parallel or in series as desired.

The insulating tube is less thick in the middle than at the ends, because the electrical tension is less in the centre, under normal circumstances even = 0, and increases towards the end, therefore sparking through the tube into the iron core is only to be feared at the ends, but chiefly because the windings of the secondary coil nearest the tube form a Leyden jar with the primary coil. The capacity of this double jar must, however, be extremely small, as otherwise the electricities separated in the secondary wire are bound by the iron core, consequently the striking distance is substantially reduced. As there is no tension in the middle of the secondary wire, no prejudicial charging action takes place there. The most suitable shape for the surface of the tube is, therefore, parabolic in section.

The battery must always be so joined up that the positive electricity enters at the closed end of the apparàtus, the negative on the contrary at the end where the primary wires appear, because the spark always starts from the positive pole, the

striking distance of the positive pole is consequently much greater. If with greater striking distances the positive electricity should appear at the open end of the apparatus, the spark would spring over to the primary wires and iron core and the apparatus might be injured. One can best decide on the correct position of the commutator of the battery by placing a disc before the discharging apparatus with one to two elements and bringing this into connection with the open end of the apparatus. With the correct position of the commutator much longer sparks are obtained. The disc must always be connected with the end of the apparatus at which the local wires appear. The disc increases the striking distance when it forms the negative pole and diminishes it when it forms the positive pole. Its action has a double cause. In the first place the disc acts inductively on the positive point, from which the electricity of the spark starts, thereby increasing its tension and striking distance but through its condenser action with the walls of the room it however essentially diminishes the tension of the negative pole, and, therefore, leads this away imperfectly, whereby a corresponding increase of the tension of the positive pole with an increased striking distance takes place. It can be dispensed with if the negative pole is connected to earth, yet this is not good with great striking distances, as the tension of the positive pole is then twice as great, a discharge of the spark to the iron core and in the air is thereby made very easy. With great striking distances, the apparatus might suffer damage by complete earthing of the negative pole. Insertion of a condenser of sufficient thickness and very slight capacity between the negative pole (open end of the secondary coil) and earth acts, however, nearly the same as a disc. To produce loud cracking and brilliant discharge sparks a thick walled condenser must be so brought into connection with the poles of the secondary coil, that the inner coating is brought into connection with the positive and the outer with the negative pole. If the distance of the poles is then made small a series of discharges in quick succession is obtained instead of a single spark, accompanied with a shrill sound, instead of a report.

The contact breaker must be so regulated that it swings very slowly, and that the closing of the battery should be made as long as possible, and the opening short and quick. The longest sparks are obtained by long closing and quick opening by hand.

The condenser consists of a tin-plate coating of about 15000 sq. centimetres, separated by lacquered paper. With our construction (different from Rumkorff's) it has only a slight influence on the striking distance, but considerably diminishes the strength of the primary spark and the splashing about of alcohol.

The platinum amalgam (silver amalgam can also be used) must be thick and free from oxide, and must stand about ¼ in. above the platinum pin in the outer vessel. The alcohol (absolute) poured over it, until the flask is pretty full, must be renewed when it has become very black with oxidized mercury. Only mercury and alcohol require to be poured into the inner vessel of the contact breaker which interrupts the current of two Daniell cells which sets the contact maker in motion.

The battery must be well cleaned and newly amalgamated before use. The nitric acid must be strong, in case of necessity one-third fuming acid should be added to the commercial acid. It is best only to fill and set up a quarter of an hour before the commencement of the experiments determined on, as it quickly runs down.

If the cells are good

1 cell gives 21^{cm}	striking distance.
2 cells give 39^{cm}	„
3 cells give $47{\cdot}5^{cm}$	„
6 cells give 58^{cm}	„

with parallel connection of the wires of the primary coil. If more cells are to be used, the connection in series is more advantageous.

One cannot go beyond 2 feet striking distance without danger, as with this intensity sparks pass into the air from all the end surfaces, which can be seen in the dark. This, therefore, appears to be the limit to be reached. For public experiments, the sparks between two balls (without discs) with 6 cells and about 18 to 20^{cm} striking distance show best.

SIEMENS AND HALSKE'S MAGNETO-ELECTRIC QUICK TYPE WRITER.*

The idea is not new of setting up telegraph messages to be despatched in suitable Morse type, as in printing, and then telegraphing the sentence by means of a mechanical arrangement with great velocity, and thus utilizing the existing telegraph lines more fully, as in a given time a greater number of previously set up messages can be despatched than was possible by means of the key and hand of the telegraphist. Setting aside the arrangement of perforated paper strips, first introduced by Siemens and Halske, and afterwards brought forward in a somewhat different form by Wheatstone, which effect the same purpose, Morse himself, already twenty years ago, tried this sort of arrangement. His type, prepared from sheet metal, had broader and narrower projections formed on the upper edge by incisions of the same breadth, which corresponded exactly to the dashes and dots of the usual letters of the Morse alphabet; the message was set up along a metal composing stick with these types, and this was then conducted by means of wheel work under the spring arm of a lever connected with the line; the composing stick itself, and its bearing, were in conductive connection with a battery, so that a current passed into the line through a stick and type as often and as long as the lever glided over a projection and an interruption of the current occurred as often as the lever fell into a notch. This apparatus, as is known, has not answered the expectations entertained of it; not to mention the wearing away of the type and other disadvantages, the frequently uncertain contact of the type with the composing stick on the one side and the lever on the other, as well as the vibratory motion produced by the quick motion of the lever caused deformation of the writing.

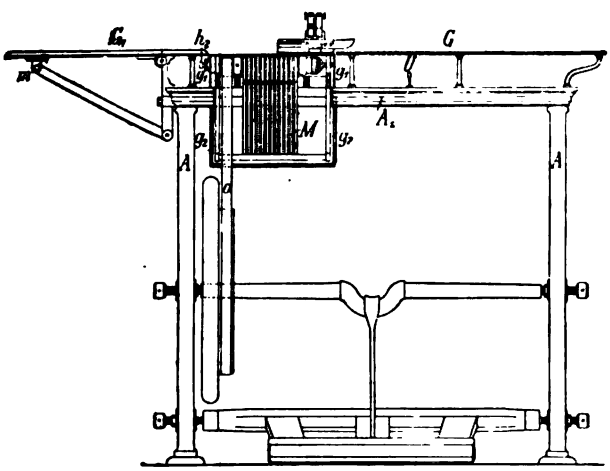
The new quick type writer has externally a certain similarity to the old Morse apparatus. But it is purely an outward similarity as the following description will prove. A very essential difference is that with the new apparatus the current does not pass through

* Journal of the Deutsch-Oesterr. Telegraphen Verein, Vol. XI. p. 271. 1862 (1864).

the types themselves, these, on the contrary, by their projections, only raise a bell-crank lever, the other arm of which then lies against a contact point and completes the circuit, which is broken, when the bell-crank lever falls into a hollow. Besides this, alternating induced currents are used, and not continuous battery currents, and this necessitates a totally different arrangement of the projections and hollows of the types, the form of which has now not the slightest similarity to that of the Morse signals, which they produce.

In Fig. 96 is given a front view of the signal sender of the new

Fig. 96.



apparatus in 1-18th of the natural size; Figs. 97 and 98 contain details of the most important parts, one-third actual size. A so called polarized inker apparatus serves at the other station as a receiving apparatus, *i.e.*, a writing apparatus, the electro-magnet of which is similar to that of Siemens and Halske's polarized relay. Its armature is pressed against the telegraph contact by a positive induction impulse, and continues to lie against it after the cessation of the current, therefore it holds the writing disc pressed against the paper, until a second induction current of opposite direction draws it away and throws it against the back contact. If, therefore, the current of a rotating magneto-inductor acts on

such a writing apparatus without interruption, it will produce a series of dots on the paper, the length of which and their distance from one another depend on the speed of rotation of the inductor. But if a dash is to appear, then immediately after the arrival of the positive current marking the commencement of the dash the circuits must be broken so that the following negative current may not act on the writing apparatus; the armature then remains against the telegraph contact and draws out the dot into a dash until the circuit is again completed, whereupon the first negative current brings back the armature to the position of rest and cuts the dash off.

It is thus the function of the types at the fitting moment on the one hand to press the bell-crank lever against its contact point by means of their projections and to complete the circuit, and on the other hand to interrupt it again by their hollows. This requires, firstly, an arrangement of the projections and hollows quite different from the shape of the Morse signals; then it follows as an indisputable condition, that the breadths of the projections and hollows, as well as the speed with which they are drawn under the bent lever, must be in a fixed proportion to the intervals of time between the induction impulses, and, therefore, to the velocity of rotation of the magnetic inductor. Hence these motions must be worked by one and the same force which sets the inductor directly in rotation, whilst this communicates its motion by a convenient gearing to the type carrier.

The inductor has the same construction as Siemens and Halske's alphabetical apparatus. The cylindrical core of the inductor, slotted on two opposite sides as regards its length, revolves about a horizontal axis between the legs (cut out on the inner side into a segment of a cylinder) of twelve vertical adjoining horse-shoe plates of tungsten steel. The longitudinal slots contain the windings of the inductor wire, laid parallel to its long axis, and are closed above them by brass plates bent over the cylindrical surface. To both ends of the inductor core solid metal pieces are fixed in which the axles are keyed; on the one side at J the axle consists, as seen in Fig. 98, of a cylindrical hardened steel pivot, rounded in front, resting in a metallic bearing *h*; on the other side the axle terminates in a conical point, which plays in a corresponding hollow in the screw *h* (Fig. 96).

Both supporting points of the axle of the inductor are on the frame, which carries and connects the magnets M and this rests on the table A of a lathe frame A A (Fig. 96) with treadle work, fly-wheel, and belt pulley. The lower halves of the magnets M pass through the top plate, and are protected by a wooden case g_2 g_2 fixed to the under side of the top plate. The inductor, and the portion of the magnets projecting above the table, are surrounded by a casing g_1 g_1 of sheet brass fixed to the table, the cover of which carries the moving mechanism of the type-carrier and the other parts of the apparatus.

On the left frame of the inductor cylinder is a small pulley

Fig. 97.

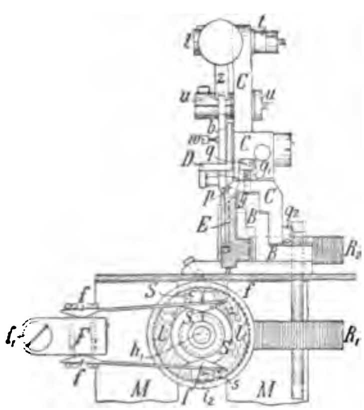
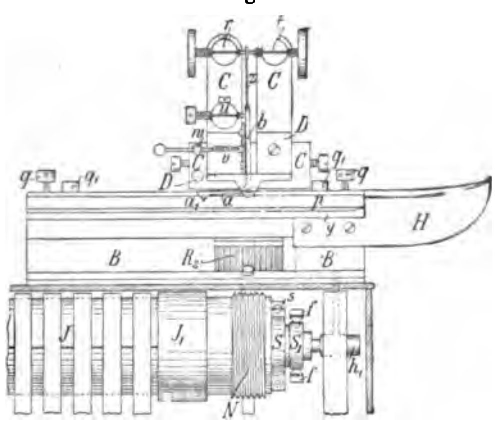


Fig. 98.



which is connected by a belt *o* with the pulley of the lathe ; therefore the current-producing cylinder is set in rapid rotation by the pedal of the lathe. A jockey pulley fixed in a fork and movable by a handle serves for stretching the belt.

On the right frame of the inductor a strong steel ring is fixed provided with a short endless screw N, Fig. 98. This gears in the teeth of a wheel R (Fig. 97) fixed to a vertical axle, whilst an exactly similar toothed wheel R_2 fixed somewhat higher to the same axle, gears with a rack fixed to the type-carrier, so that the screw N, by means of the wheels R_1 and R_2 transfers the motion of the inductor to the type-carrier.

One end of the windings of the inductor is fastened to its

metal core, and is therefore continuously in conductive connection with its axle, and through this with the metal parts of the apparatus. The other end i_2 of the windings (Fig. 97), is led through a perforation in the frame J, which is fitted with a small insulating tube of ebonite, and fastened by the screw S (Figs. 97 and 98) to the metal ring S S which is pushed over a continuation of the frame in question, but insulated from it by a layer of ebonite $l\ l$. The ring S S has projections, at two diametrically opposite points; it is split open on one side through one of these projections and is firmly held together by a screw passing through at this point, and pressed against the insulating base. To make turning impossible, the opening arranged in the other projection at the underside of the disc S S, for the passage of the wire i_2, is lengthened by a short tube, which reaches a short distance into the corresponding channel of the metal piece J_1.

Two metal springs $f\ f$ which are fixed to the insulated metal piece F, slide continually with their free ends on the front stop S, of the piece S provided with a steel ring. Therefore the wire end i with the metal piece F and its clamping screw f_1 serving for the fixing of the leading wires are in constant conductive connection.

The parts of the apparatus which effect at the desired moment, the interruption and renewal of the circuit, stand on the cover of the metal case $g_1\ g_1$ inclosing the inductor, they are shown in Figs. 97 and 98 in one third of their natural size, 97 being a side view and 98 a front view. The under portion B B provided with the longitudinal groove n firmly fixed on the cover of the casing in question, serves specially for guiding the type-carrier. The upper part C C is fixed to it by means of the screws $q_1\ q_1$ and q_2 which pass freely through somewhat wider perforations of the piece C, and find their nuts in the piece B_1, the screws $q\ q$ which have their nuts in C and button to the piece B with their ends, serve for adjusting the position of C C. Such an adjustment is necessary, because the slider $p\ p$ forming a portion of C tapered inwards and here covered with steel catches over the upper oblique surface of the type-carrier E and serves to guide it. On the front side of C C the angle piece D D is attached but insulated from it, in which are the axle bearings of the bent lever $a\ b$. The two upright continuations of C C bear at their ends the little columns r and t fixed to them but insulated from them, and pro-

vided with contact screws, which are provided at the back, as seen in Fig. 97, with screw terminals for attaching the conducting wires. Below *r* is a third similar column *u* fitted with a contact screw also insulated. The interruption lever *a b* consists of two portions insulated from each other, the upright standing little stem *b*, fixed directly to the axle, the upper end of which, formed of the spring tongue *z*, plays between the contact screws *r* and *t* and the light insulated angle piece *a* fixed to it. The latter carries at the end of its horizontal axis, a prism of agate, with its edge *a* turned upwards, under which pass the types. When this edge is raised by a projection of the type, the lever with its tongue moves over against the contact screw *t*; if on the other hand a hollow of the

Fig. 99.

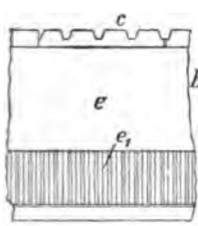


Fig. 100.

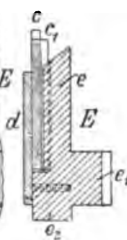
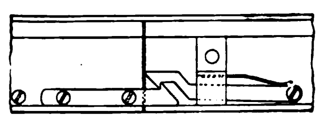


Fig. 101.



type lies under the edge *a*, then the tongue is drawn against the other contact screw *r* by the spring *v* fixed to the vertical leg of *a*. The third contact screw *u*, which strikes farther below against the solid rod *b*, serves only for the greater safety of the play, since it prevents the tongue *z* bending too much, and the edge *a* from catching in the hollows of the type.

The type-carrier E is shewn in Figs. 99 and 100; Fig. 99 shews the back view, and Fig. 100 the section; Fig. 101 shews the way in which two carriers are joined. With the lower projection e_2 the carrier slides in the groove *n* and the channels G and G_1 (Fig. 96) forming their extension on both sides, of which the latter can be depressed after taking out the bolt *m* when the apparatus is not in action. At its upper portion the carrier is led through the uppermost part of the channel *y y* forming the piece B and through the slider *p p* engaging the upper oblique surface of C as shewn in Figs. 97 and 98. An angular plate H widening

with a slight curvature gradually outwards towards the incoming carrier, leads the beginning of the carrier or the several carrier joints, gently and without concussion into the guiding channel, the ends of which are also somewhat curved round for the purpose on this side.

At the back of the type-carrier is the rack e (Fig. 100) in which the teeth of the wheel R_2 gear, and thus bring about the forward motion of the carrier. On the front side of c turned to the slit, is a series of vertical grooves, which must exactly correspond to the teeth of the rack e_1.

In the slit between the part e and the screwed on front rim of the carrier, the types c are set, which have the shape of rectangular pieces of sheet metal provided at the upper edge with corresponding incisions, and are as thick as the breadth of the slit. They were first cut from sheet brass, but they are now made of cast type metal and for greater protection against wear are covered with a galvanic deposit of nickel; each type is marked on the front flat side with the letter which its projections and depressions produce in Morse writing. In order to bring the type in a determined position to the teeth of the wheel R_2, consequently also to the instantaneous position of the inductor, each of them has on the front edge a fillet c_1 which catches in one of the grooves of e.

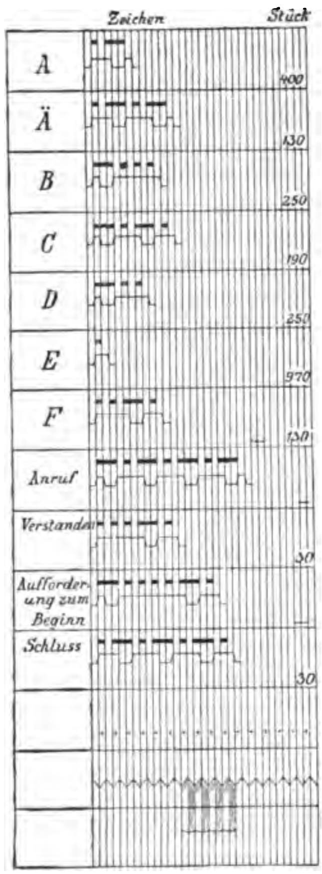
Each complete revolution of the inductor moves the wheel R_1 and with it also the wheel R_2 and the rack e_1 one tooth forward. With each revolution of the axle of the inductor, two inductive impulses of opposite direction take place in the wire of the coils, (of which each two similarly directed impulses produced by the pulling off of the one side of the iron core from the one magnet pole, and its approach to the other pole, almost coincide in point of time and act as one current because the respective side of the iron core has already entered the sphere of action of the second pole, before it has left the first) and with the first half of the revolution a negative, with the second half a positive; if further in the position of rest, from which the turning begins the prism a_1 lies over a gap in the rack, then by further turning the inductor so long as the circuit is not interrupted, on one side to the earth, and on the other side to the line, a negative current is always sent into the line as often as the prism a_1 is over a gap, and a positive current when it is over a tooth of the rack.

The necessary interruptions of the circuit are brought about, as already mentioned at the beginning by the lever *a b*; the contact between the tongue *z* and the screw *t* forms part of the circuit; the latter is completed as often as a_1 is raised, and the tongue is thereby pressed against the contact screw *t*, it is on the contrary interrupted when a_1 is lowered, and the tongue lies on the insulated contact. If a strip of tin is therefore placed in the type-carrier without incisions and of suitable width, so that *z* is continuously pressed against the contact screw *t*, all the currents produced will arrive at the other station in the alternating direction, and a series of dots will be formed in a polarized apparatus inserted there, since a positive current always brings over the printing lever against the paper, but the following negative current takes it back against the insulated contact. But if a dash is to be obtained, the circuit must be interrupted as often as the negative current is produced, so that only the positive impulses can be sent into the line, *i.e.* the type must have incisions on the whole length of the dash over the gaps of the rack, or, after the positive induction impulses, which mark the commencement of the dash the circuit must be interrupted for the whole length of the dash, and up to the arrival of the negative current which is to end the dash, so that in the interval no current whatever can arrive at the apparatus, the lever is therefore obliged to remain on the telegraph contact until it is again thrown against the rest contact by the first returning negative current, that is the type must have at the commencement of the dash a small projection above a tooth of the rack, then a wider gap and at the end of the dash again a projection over a gap in the rack. The last contrivance is preferable, as it causes a less sudden alteration of the polarity of the core of the electro-magnet.

Accordingly the upper edges of the type had a shape for the different letters of the Morse alphabet of which Fig. 102 gives some examples. The vertical lines of this figure correspond to the divisions of the rack of the composing stick in such a way that the 1, 3, 5, 7 spaces &c., represent the gaps, the 2, 4, 6 &c., the teeth of the rack. All the types begin with a projection in the second space, therefore over the first tooth, and in all the last projections ends over a gap, so that with each type the last current which it sends to the other station is a negative one, which brings

back the lever into the position of rest. Behind the last projection there always follows a gap of the breadth of a tooth, so that each type demands an even number of spaces and a whole number of revolutions of the inductor. At the same time this has the effect of producing a greater space—viz. three dots—between the individual letters when there is a row of several type following each other.

Fig. 102.



The numbers placed by the side of the types are proportional numbers, which show how often the corresponding signal is required on the average in printing.

The joining up of the apparatus is represented in the accompanying sketch Fig. 103.

The line is brought to the lever of an interrupting switch U fixed on the base plate—shewn in Fig. 96—its right contact plate is connected with the receiving apparatus, the windings of which are to earth at the other end; from the left contact plate a wire leads to the bearing of the axle of the bell-crank lever; the contact screw *t* is permanently in connection with the metal piece F and through this, the springs *f f*, and the ring S_1 with one end i_2 of the inductor windings; the other end of the inductor wire is put to earth, and a wire is also led to earth from the contact screw *r*, in which a polarized relay P is inserted. It is evident that the connection between the inductor and the line is only set up, if the arm *a* of the lever is raised by a projection of the type On the contrary at the moment that the

tongue lies on the rest contact a current coming from the other station can get to earth through the relay P ; an immediate break is therefore possible in case the writing does not arrive clear.

In what precedes the apparatus is described as at present constructed (in the year 1864) ; the samples already in use (made in the year 1862) have a somewhat different construction and on that account also are connected up somewhat differently.

The entirely metallic bell-crank lever *a b* provided with a steel prism instead of one of agate, consists of a single piece, and is in conductive connection with the other metal parts of the apparatus, whilst the insulating layer between the parts D and C is wanting ; of the little pillars bearing the contact screws only *r* needs to be

Fig. 103.

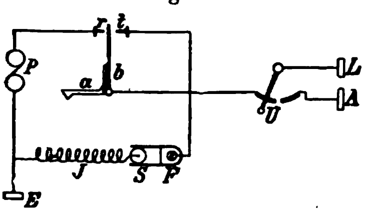
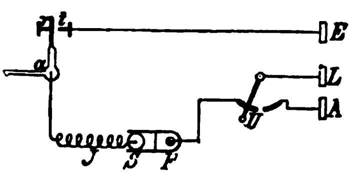


Fig. 104.



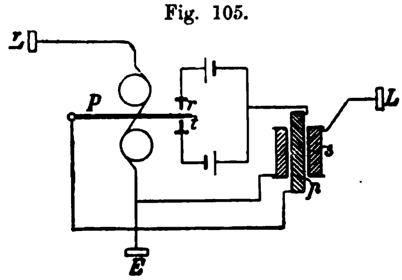
insulated. The interruption of the current then takes place not between the inductor and line, but between the inductor and earth. The connections are as sketched in Fig. 104.

The metal piece F in contact with the end i_1 of the inductor wire through the sliding springs, is connected with the left contact plate of the switch, and through this and the lever, when in the speaking position, with the line ; the other end of the inductor wire is in conductive connection with the lever *a* through the metal parts of the apparatus but is insulated from the earth by the polished base plate. On the contrary the telegraph contact *t* is connected to earth. The circuit from the inductor to the line is therefore always closed in this case ; the circuit from the other end of the inductor wire to earth is on the contrary interrupted, so long as the tongue lies on the rest contact. An interruption of the correspondence arriving from the other station is not possible with this arrangement.

Another alteration of the apparatus now being introduced, could not be included in the drawing ; it consists in the upper

part of the apparatus being displaced so far to the right, that the prism a_1 is exactly over the point where the wheel R_2 catches the rack e_1. When, namely, the joint at the connecting places of two pieces of carriers gapes somewhat—which is hardly to be prevented—there occurs at the moment this place comes into gear with the wheel R_2, an irregularity in the motion, which may disfigure the signal of the type, which is at the moment directly under the prism. This difficulty is obviated by the removal of the lever referred to, so that just at the moment when such a joint reaches the wheel R_2, the prism is always over a hollow between two types, the line is therefore interrupted.

Fig. 105.



The rate of telegraphing messages set before-hand by means of the apparatus described, considerably exceeds what could formerly be reached. The apparatus already constructed allow of a rate of 60 to 80 words a minute, but there is nothing to prevent the speed being considerably increased.

The distance over which the apparatus will work is very considerable, so that direct correspondence without translation appears possible between most of the principal European towns. If for all that a translation could not be somewhere avoided, it could be arranged according to the above diagram, Fig. 105. A polarized relay P, joined up in the arriving current at the transmitting station, closes (according as its tongue lies against the rest or against the telegraph contact) one or other of two oppositely connected batteries, both of which send their current through the primary coil p but in the opposite directions. In consequence of this the secondary coil S connected up between earth and the extension of the line, sends a positive induction impulse into it, as often as the tongue is laid against the telegraph contact by means

of the arrival of a positive current, and a negative as often as the tongue returns to the rest contact.

The apparatus described has been set up by way of experiment about a year ago, at several Prussian telegraph stations, and used for the regular despatch of messages. As already pointed out, the attendant advantage is that with one conducting wire, 6 or 7 times as many words can be sent as by hand work with a Morse Key. Further there is no likelihood of error of the telegraphist in sending the message, for the sentence can be verified before despatch. Finally the printing is almost mathematically correct, there are consequently much fewer errors of reading. On the other hand, setting up the messages requires almost as much time as hand telegraphy, and the repeating of messages is less easy, because a greater number of messages must always be sent consecutively without interruption. The new system, therefore, will only be of special use between such distant main points for which the existing wires do not suffice, in order to forward the accumulating messages quickly enough. In these cases, certainly no labour is saved at the receiving and despatching stations, and therefore a message despatched with overworked lines, does not arrive more quickly at the place of its destination; but the laying and maintenance of new lines between the places in question is avoided, and the accumulation of undispatched messages in times of great congestion, where it depends especially upon quick forwarding, prevented. If it is further considered that there are technical impediments to the further increase of conducting wires along railway lines which will be considerably increased with the further development of telegraphy, and that each new wire suspended from the posts reduces the safety of the service of the existing wires, it cannot be denied that the new apparatus is of considerable importance.

ALTERED CONSTRUCTION OF SIEMENS AND HALSKE'S QUICK TYPE WRITER TO BE WORKED BY BATTERY CURRENTS.*

With the magneto-electric quick type writer described and represented in this journal in the 11th annual issue, 1864, † the use of induction currents has not proved in the long run as beneficial as at first thought, one was entitled to hope. The difficulties arising in its use were partly due to the fact that with the short duration of the induction currents even the slightest alteration of form of the projections of the type even through wearing away of the corners, and the slightest shifting of the type, produced false signals, partly to the circumstance that induction currents are influenced in a greater measure than battery currents by the faults of insulation already existing in the line.

Therefore the existing apparatus at the request of the Royal Prussian Telegraph Office was altered by abandoning magneto-inductors and using battery currents. The construction which Messrs. Siemens and Halske have finally given to this apparatus for the purpose, is shown in Figs. 106 to 108.

The alteration is confined to the signal sender. The receiving instrument is the same as formerly, namely, a polarized Morse inker apparatus. Conformably to the nature of this apparatus the signal sender had, therefore, to be arranged in such a way that it, just like the magneto inductor formerly used, sends currents of alternating direction into the line; that it therefore connects, for example, the zinc pole of the battery with the line, and its carbon pole with earth, when a signal is to appear at the other station, and that inversely it connects carbon to line and zinc to earth, when the signal is to be interrupted and the armature lever of the Morse is for that purpose to be brought back to the position of rest.

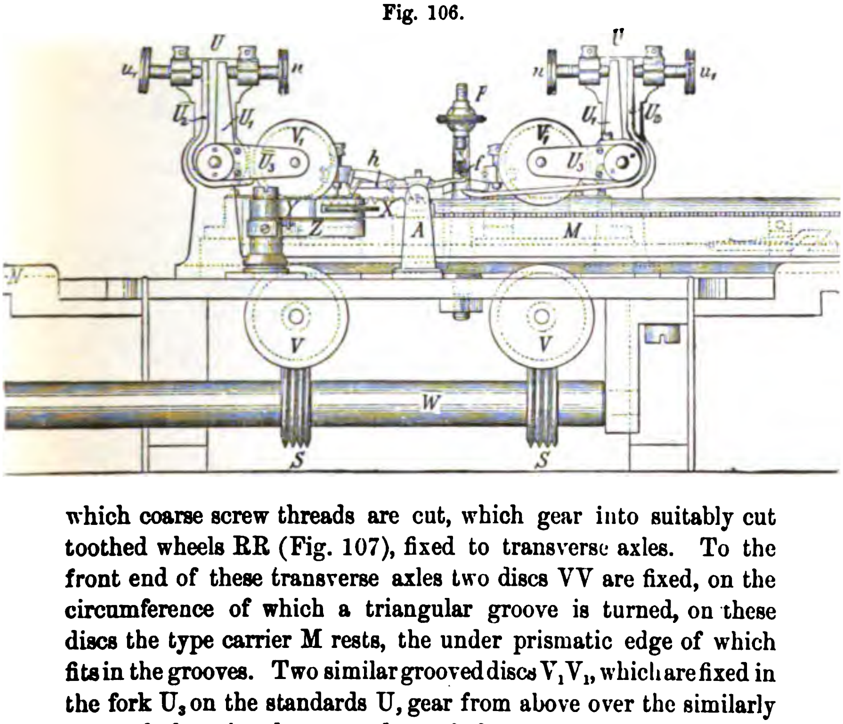
Fig. 106 shows the front view, Fig. 107 the upper view of the sending apparatus, Fig. 108 the view of the contact lever after removal of the part of the apparatus in front of it and the slide

* Journal of the Deutsch-Oesterr. Telegr. Verein, Vol. XIV. p. 29. 1866.
† See the previous paper in this collection, p. 19.

which those parts hide in Fig. 106 ; in all cases in 3-10ths of the actual size.

The under frame with pedal, lever, and fly-wheel has retained the previous construction and is, therefore, not shown here. A small leather belt carried over the flywheel and a small pulley fixed on the horizontal axle WW transfers the motion of the flywheel to that axle which here, as the inductor is omitted, merely serves to push the type carrier forward. It carries for this purpose two short cylindrical pieces S (Fig. 106), on the surface of

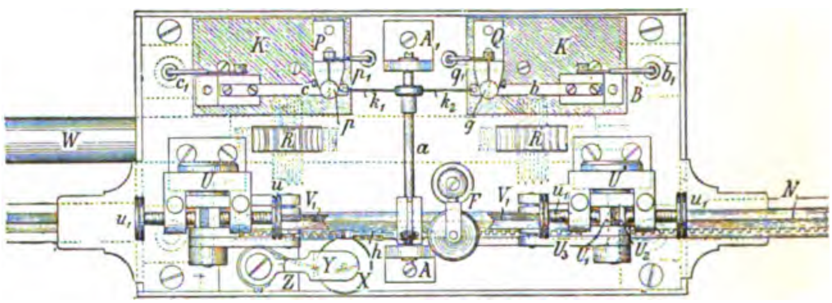
Fig. 106.



which coarse screw threads are cut, which gear into suitably cut toothed wheels RR (Fig. 107), fixed to transverse axles. To the front end of these transverse axles two discs VV are fixed, on the circumference of which a triangular groove is turned, on these discs the type carrier M rests, the under prismatic edge of which fits in the grooves. Two similar grooved discs V_1V_1, which are fixed in the fork U_3 on the standards U, gear from above over the similarly triangularly-pointed upper edges of the carrier, and are pressed against it by strong springs U_2; the approach of the disc V_1 to the carrier is limited by the first of the set screws uu and u_1u_1 carried by the standards U, which rest against a massive continuation U_1 of the fork U_3, while the other two serve for straining the springs U_2. These four grooved discs VVV_1V_1 form the guides of the type

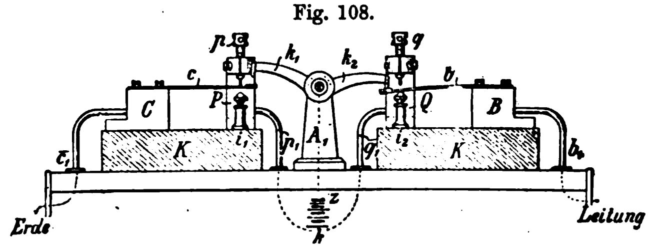
carrier, and the first two cause at the same time its forward motion. The channels NN, projecting on both sides, form extensions of the guide and serve for bringing up the new carrier as well as for the preliminary support of the pieces already passed.

Fig. 107.



The pocket for the types is at the front side of the carrier, as seen in Fig. 107. A spiral fixed to the fork of the right disc V_1, glides over the heads of the types and presses them immediately before they reach the place of contact into their normal position, and in order to prevent a possible shaking of the type at the moment

Fig. 108.



they are under the nose of the contact lever, there stands at this place before the carrier a fifth horizontal roller X, borne by the fork Y, which is laid against the respective type by the spring Z and presses these hard against the carrier.

The lever *h*, which with the prism fixed on its left arm lies on the upper edge of the type passing below it, and by the rising and falling of which the projections of the types produce the necessary change in the direction of the current can be seen in each figure ;

it rests on a long axle a (Fig. 107), which has its pivots in the angular pieces A and A_1; the spring f working on its right arm holds the prism on the other arm in constant contact with the types.

The axle a, which takes part in the motions of the lever h, rigidly connected to it, bears at its other end two arms, k_1 and k_2, also fixed to it, which effect the commutation of the circuit. In Fig. 108 the front view of this part is specially shown —a longitudinal section immediately behind the pulley W—the upper view is shown in Fig. 107. On each of two blocks of insulating black material KK is fixed a metallic angle-piece P or Q and a metal block C or B; the first carry the upward turned contact screws p or q; on the latter are screwed horizontal spring metal strips c or b; which, left to themselves, would lie against those contact screws. The ends of these strips are directly under the contact pins, fixed to the arms k_1 and k_2, so that now one, now the other of these arms comes in contact with the corresponding strip, according to the position of the angle a, and the lever h presses it up, and thereby breaks its contact with the contact screw p or q, whilst the other arm lets go the strip lying opposite to it, so that it can lie against the contact screw. The insulated pillars which stand under the strips are not contact points but only have the function of catching up the strips so that they shall not be bent too much, and thereby limit at the same time the play of the lever h.

The body of the apparatus and the axle a are permanently connected with the zinc pole of the battery, the contact screws p and q are connected with the carbon pole of the battery through the wires p_1 and q_1. The wire b_1 leads from the strip b to the conductor, and lastly, the strip c is connected through c_1 with the earth. If the prism of the lever h rests on a projection of a type, the arm k_1 is raised and out of contact with the strip c, which, on the contrary, lies against the contact screw p, the arm k_2 is, on the contrary, depressed, stays in contact with the strip b and breaks its contact with the screw q; now the zinc pole of the battery is connected through k_2 and b with the line, the carbon pole, on the contrary, through p_1, p and c connected with earth, and a negative current passes to line, which at the further station lays the writing lever against the paper. But if the prism of h falls

into a hollow of the type, the arm k goes down, comes, after raising of the contact between p and c, in contact with c_1, whilst on the right side the strip b, which has been set free, lies against the contact screw q_1; now a positive current goes to line, which carries back the lever to the rest position at the other station.

This consideration of the manner of working shows further, that the types must now have a shape different from that in the apparatus working with induction currents; the projections must correspond simply in order and length with the dots and dashes, the gaps in the types on the contrary with the spaces between the signs.

As there would be no object in allowing the message sent to appear also on its own apparatus, this is cut out on sending; there is for this purpose a simple commutator, by means of which, as desired, either the current sender can be inserted with the battery, or, for receiving, the polarized Morse apparatus between conductor and earth. Up to now, moreover, only the central Berlin station is furnished with three current giving apparatus, the corresponding distant stations have only the polarized Morse as the receiving instrument, which can then be joined up in the usual way between the key and earth; the queries and repetitions are given with the ordinary key and received on a blue inker; besides the printing now appears so correct that there is seldom any occasion for extensive explanations.

ELECTRIC TELEGRAPHY.*

Electric telegraphy, or the art of writing at a distance, so called from the Greek *tele*, distant, and *graphein*, to write, is altogether a child of our century, so rich in great discoveries and inventions deeply influencing the social life of mankind. Older communications regarding proposals or contrivances for sending messages from one room to the neighbouring one by means of frictional

* Part 22 of the popular collection of scientific addresses, edited by Rud Virchow and Fr. v. Holtzendorff, 1866.

electricity, then alone known, certainly already existed; they were, however, only fruitless electric toys, which cannot be looked upon as the first step of existing electric telegraphy.

The wonderful discoveries of the learned Italians, Galvani and Volta, at the close of the last century, first led to the knowledge of the continuous electric or galvanic current, and thereby furnished the basis of the electric telegraph. Alessandro Volta, who first recognized that different metals became oppositely electrified by contact, and that Galvani's frog's legs suspended from an iron railing by means of a copper hook were convulsively moved because an electric current traversed them, who further, by means of this knowledge, was led to the construction of the galvanic battery, and made us acquainted with important phenomena of the permanent galvanic current produced by it, rightly deserves to be called the true father of the electric telegraph.

One of these properties of the electric current here assumed to be known consists in its decomposing acidulated water into its chemical elements, oxygen and hydrogen when it passes through it. A few years only after Volta's discoveries became known, in the year 1808, the physician Dr. Sömmering, of Munich, made the proposal to use this property of the electric current to connect distant places by means of the electric telegraph. He intended to connect the two places by as many insulated wires, *i.e.*, wires separated at all points from one another and from the earth by non-conductors of electricity, as there are letters in the alphabet. At each station a glass vessel filled with acidulated water and a key-board were to be set up. The liquids in the two glass vessels were in conductive connection with one another by a separate wire, the ends of which dipped into the water. Besides in each of the glass vessels twenty-six gold tips were fixed, each of which was plainly marked with a letter of the alphabet. The similarly marked tips were in conductive connection by means of one of the wires. If, therefore, at one of the two stations, one of the two tips with its connected wire was brought into conductive connection with one pole of a galvanic battery or pile, of which the other pole was connected with the 27th wire, which joined up the liquids in the vessels, by pressing down the similarly marked keys of the keyboard an electric current must arise which started from one pole of the battery, traversed

the wire to the other station, there passed from the gold tip through the water to the common return wire, and returned thence to the other pole of the battery. A development of gas bubbles then took place at the respective gold tip, by which the observer was able to discover which key his correspondent had pressed down, which letter of the alphabet he consequently wished to denote. It, therefore, only required that the communication to be made should be spelt out in slow succession by the pressing down of the corresponding keys to make it comprehensible to him.

Sömmering brought this first electric telegraph to the notice of the Academy of Munich. It has not, however, come into practical use, for the large number of wires necessary, the difficulty of insulating them. and, besides, the novelty of the thing prevented a practical application being carried out. Notwithstanding this Sömmering deserves the credit of having first recognized the great practical advantage which Volta's discovery was in the position of bringing to mankind, and one must, therefore, call him the inventor of the electric telegraph.

The greatest hindrance to the application of Sömmering's telegraph consisted, however, in the great number of wires which it necessitated. Professor Schweigger, of Erlangen, therefore proposed to use only two instead of the twenty-six gold tips, and to connect these by means of two conducting wires. By means of a suitable mechanical arrangement, whoever wished to make a telegraphic communication should be in the position to bring his battery in one or other direction between the two wires, *i.e.*, either to bring the positive or copper pole of the battery into conductive connection with the first, and the negative or zinc pole with the second wire, or inversely the positive with the second and the zinc pole with the first. Since, as is known, the hydrogen which is produced at that gold tip which is connected with the negative pole of the battery, occupies twice as much space as the oxygen simultaneously produced at the other pole, therefore a careful observer could recognize the two tips by the greater number of gas bubbles, which formed at the one or other point, with which his correspondent had connected the negative pole of his battery. Schweigger now proposed that an alphabet should be agreed to, in which each letter should be represented by a determined sequence

of gas evolutions of both kinds—that is greater development of gas at the first or the second tip. If the sender as well as the receiver of the telegraphic communication had this alphabet in his head, then the same thing could be attained with two wires that Sömmering obtained with twenty-seven wires.

Schweigger's proposal could not have a practical result any more than Sömmering's, for the knowledge of the laws of the galvanic current was too incomplete, and technical knowledge not sufficiently extended to be able to overcome all the difficulties opposed to its accomplishment. It was, however, of great importance, as it first showed that by means of a single circuit complete telegraphic correspondence could be effected by compound signs for the separate letters or other telegraphic signals.

A second period of the gradual development of the electric telegraph is connected with Oersted's discovery in Copenhagen in the year 1820. Oersted found that the electric current deflects the free swinging magnetic needle, when it is led parallel over or under it, and that the direction of this deflection is dependent on the direction of the electric current.

In this way a new means was obtained of recognizing the existence and direction of an electric current in a wire. Ampère, in Paris, who studied this property of the electric current more closely, made the proposal, as early as 1820, to employ the deflection of the magnetic needle instead of the decomposition of water for the construction of an electric telegraph. He proposed to hang as many magnetic needles at the distant station as there are letters in the alphabet. A wire was to be led under each needle which went to the other station and back, and through it electric currents could be sent by means of a key-board. The needles were to carry light screens which concealed the letters standing behind them. If the needles were deflected one after another, the letters previously concealed would be seen in a similar sequence, and it was only necessary to read them in order to get the message.

Fechner, of Leipzig, busied himself with the simplification of this proposal as Schweigger modified Sömmering's proposal. He wished to employ only two wires and one magnetic needle, and to use its deflections to the right or left as elementary signals from which an alphabet should be compounded. Schweigger and

Poggendorf had by that time found that the force with which the electric current led above or below the magnetic needle deflects it may be considerably increased by carrying the wire round the needle in several convolutions in the same direction. In order to effect this without giving the electricity the chance of passing from one convolution to another, the wires were thickly covered with silk. As silk does not conduct electricity, and, therefore, insulates it, the electricity could not pass directly from one wire to the next, but must traverse the whole length. By means of such a Schweigger multiplier a very weak current becomes able to deflect a magnetic needle quickly and powerfully. Fechner recognized from this the possibility of connecting places far distant from one another telegraphically, and calculated the number and size of pairs of plates or cells which the battery had to have for this purpose.

Thus the scientific foundation for a practical electric telegraph was laid, and in fact the needle telegraphs still in use in many places, especially in England, agree essentially with Fechner's proposal.

A third period in the development of telegraphy is connected with Arago's discovery in Paris and Faraday's in London. Arago found that the electric current made iron magnetic, which was in its neighbourhood, that the magnetism so produced in hardened steel was to a great extent permanent, whilst soft iron lost it again as soon as the electric current ceased. This action was especially powerful, when, as in the Schweigger multiplier, the current was led round an iron rod in several convolutions. The iron rod thus becomes a powerful magnet which attracts neighbouring iron. If the conductive connection of the wire coils with the poles of the battery is anywhere broken, the magnetism of the iron rod ceases, and this allows the attracted iron to fall again. The action described of such an electro-magnet is particularly powerful, if the piece of iron surrounded with an insulated wire has the shape of a horse-shoe, and its two end or polar surfaces are opposite to the iron plate to be attracted.

Faraday's discovery is equally important. If two metal wires are stretched parallel to one another at a slight distance apart, and the ends of one wire are connected together in a long loop; a short electric current is produced in this, if the ends of the other wire

are connected with the poles of a galvanic battery, and an electric current therefore traverses it. As long as this current continues, no current is observed in the neighbouring wire, but when it is broken, there arises in the neighbouring wire a short current of the same strength as the first but in the opposite direction. This is expressed by saying that the starting of an electric current produces or induces in neighbouring conductors a short current of opposite direction, whilst its stoppage produces a similar current of like direction. Such transient currents of alternating direction are equally produced in conductors of electricity by the appearance or disappearance of magnetism in iron or steel. This phenomenon is specially powerful if a coil of covered copper wire is placed on a magnetic steel bar, or the steel magnet is drawn quickly out of it. But in place of this a soft iron bar can be placed in the coil of wire and the bar be magnetised in the way already described by the electric current of a galvanic battery, and by breaking the connection of the battery the magnetism be caused to disappear again. In both cases short currents of opposite direction are obtained in the wire coil, which are known as induced or magneto-electric currents.

Gauss and Weber, in Göttingen, made use of this discovery for the construction of an electric telegraph. This differed from those previously used essentially in the electric current being produced not by a galvanic battery but by steel magnets. For the rest they followed Fechner's proposal to use only one conducting circuit and to compound the alphabet out of groups of two elementary signs, the deflections of the needle to the right and left. Instead of the light magnetic needle Gauss and Weber used, however, a stronger bar magnet with a small mirror, in which they observed, by means of a telescope, the image of an illuminated scale with narrow divisions. As by this means the slightest turning of a magnet bar hung to a silk thread could be clearly perceived, the coil of wire placed between the poles of two powerful bar magnets at the other station, which was connected with the ends of the two leading wires at that end, only required to be moved a little towards the one or the other magnet pole and back again in order to make a clear movement of the scale visible in the mirror to the right or left.

This telegraph of Gauss and Weber deserves special notice.

because it was the first actually carried out, and served from 1833 to 1844 for the telegraph connection between the Magnetic and Astronomical Observatory at Göttingen. In the latter year this first conductor carried through the town of Göttingen was struck by lightning, which completely destroyed it.

Incited by Gauss and Weber's brilliant success, Steinheil, in Munich, busied himself with the practical production of the electric telegraph. His telegraph installation which connected the Academy buildings in Munich with the Observatory in the neighbouring town of Bogenhausen, and had two intermediate stations, was completed in the year 1837, and was thus the second which actually came into existence. Steinheil also made use of the magneto-electric currents produced by steel magnets instead of galvanic currents. In the receiving apparatus he led the multiplier wire around two small magnet needles, so placed behind one another that the south pole of the one and the north pole of the other were near to one another. If an electric current passed through the line and multiplier wire which was in circuit with it and therefore formed a part of it, then both needles were deflected in the same direction to the right or left, according to the direction of the current, consequently one of the neighbouring ends of the needle came out of the multiplier whilst the other moved back. Steinheil now provided these middle needle ends with small reservoirs filled with colour, which on the further side had fine pierced points. A strip of paper was carried past these points by clockwork. If a message was sent one or other point touched the paper according as a positive or negative current passed through the line and left behind it a coloured dot. The message was in this way written down on the paper strip. Steinheil, therefore, has the merit of having first proposed and practically introduced a writing telegraph. Steinheil also first used acoustic signals, as he placed little bells of different tones opposite the outer ends of his magnet needles not provided with a colour reservoir. These served not only for the purpose of calling the attention of the operator, he was also able to understand the meaning of the communication by the sound. Finally Steinheil also succeeded in reducing the number of necessary leading wires to a single one, since he completed the circuit of the electric current by means of the earth itself. As is known, water conducts

electricity, although only slightly when in the pure condition. If one, therefore, sinks at each end of an insulated conductor a pretty large metal plate in open water or in damp earth, the conductive damp earth replaces the second or return conductor. As a wire or any other conductor conducts electricity so much the better the greater its section, and as the current passing from one sunk plate to the other can spread itself in the damp earth surface—indeed, strictly considered, it must pass through all its parts—the earth takes the place of a conducting wire of infinite thickness, which, therefore, conducts very well, although formed of badly conducting material.

Simultaneously with Steinheil, Schilling von Cannstadt, of the Russian Baltic provinces, busied himself with improving the electric telegraph. In principle, his telegraph was similar to Fechner's proposal, yet he introduced several practical improvements. Among others he combined with it an alarm—a clockwork with bells, which was released on the first deflection of the needle.

As appears from what precedes, the notion of the electric telegraph has slowly developed in the course of a quarter of a century. On each scientific discovery, by which better means were given for its realization, proposals immediately followed for the better construction of the electric telegraph. The question, therefore, cannot be answered who was the actual inventor of it. The invention was the product of the intelligence of our century, which differs so essentially from all previous centuries in being directed to the study of natural phenomena and seeks to fathom its laws in order to make them serviceable to man. Although in earlier times such an endeavour had frequently arisen, and a considerable store of knowledge and experience had in consequence already been collected, it remained known in only a small circle. Only since the invention of printing, in consequence of which the idea or observation of one soon became the general property of the whole civilized world, could the prodigious stores of knowledge and experience be collected, which forms the true wealth of the human race and the inexhaustible source which each year brings its new forces and new means to improve and beautify its existence.

Whilst the professor collects scientific observations, extends and systematically sets them in order and explains them, the craftsman,

the technical man, only speculates how he can apply this extension of knowledge to the improvement of his trade or for new productions. Each thought works productively and produces in other heads new ones, which in themselves perhaps impracticable, yet on their side again may form the starting point of important inventions. Thus has telegraphy arisen, and by degrees built up its present importance, which was hardly to be conceived a few generations ago.

Up to the end of the third period, some thirty-five years ago, it was German scientific men in particular who grasped and fostered the idea of an electric telegraph. Industry now takes pessession of these notions, and we see a race amongst all civilized nations to begin practically to develop and realize them. In this fourth or practical period which is now beginning, the Anglo-Saxon race first took the lead, which is distinguished by a more practical direction than others. The American Morse and the Englishman Wheatstone gained special merit in the construction of practically applicable telegraph apparatus, the proper laying of lines, and the introduction of the electric telegraph into public life. As the Morse telegraph lies at the foundation of the present great telegraph network of the world, it will be here described more at length, whilst the small space of this paper only permits of a hasty review of the other numberless constructions. Morse used for the construction of his telegraph Arago's above mentioned discovery, that the electric current magnetizes temporarily iron in its neighbourhood. If the wire coils of an electro-magnet are inserted between the end of a telegraph conductor and the earth, the armature will be attracted by it so long as a current passes through the line, and falls away again when the current is interrupted. Following Steinheil's example, Morse led a strip of paper over a rounded point, which was fixed at the end of a lever revolvable around a pivot. The armature of the electro-magnet was fixed to this lever. If a current passed through its windings and if the armature was thereby attracted, the point was pressed a little into the paper and formed a dot on it, when the attraction only lasted a moment, a dash on the other hand when the current lasted longer. At the other end of the line was a push, also called a key. By pressing it down the person who wished to send a message placed the conductor joined up to the push in con-

nection with one pole of an electric battery, the other pole of which was to earth. The circuit of the battery was now completed, the current passed through the whole circuit, consequently also through the windings of the magnet inserted at the other end of the line. This attracted its armature and a stroke was commenced on the paper strip, passed through by the clockwork, which lasted until the current was again interrupted by the release of the push drawn back by a spring.

The telegraphist could consequently form dots or dashes as he desired on the paper strip and separate them from one another by as long intervals as he chose. If he had an alphabet in his head combined of two elementary signs, in this case, therefore, of dots and dashes, as Schweigger proposed, he could easily and safely make his correspondent understand him.

The Morse telegraph differs from Steinheil's, essentially in that the former used electro-magnets instead of magnetic needles, and combined his letters and various signs represented on the paper strip, out of dots and dashes, instead of dots in two lines. Every telegraph apparatus which makes use of this alphabet combined of dots and dashes, is called a Morse telegraph, however much it may otherwise differ from the original Morse instrument.

As the electric current is very much weakened by having to pass through long and thin wires, very strong batteries were necessary to give the electro-magnets sufficient strength for impressing the paper strips. This difficulty was removed by connecting a so-called relay (or passer-on) with the writing apparatus. This relay consists of a small electro-magnet, which is inserted in the line. Above the poles of this magnet is an armature which turns easily about an axle placed at the side. The motion of the armature is limited to a small amount by two stops, of which one consists of metal, and whilst the magnetism draws it against this stop, a spring draws it back again to the other, when the electric current ceases. For the production of this slight motion, a very weak current suffices through the conductor and the windings of the relay. The armature lever of the relay and its metallic stop or contact, form parts of the circuit of a second battery at the place of the receiver, in which also the electro-magnet of the writing apparatus is inserted. This auxiliary battery is therefore closed, and the armature of the writing magnet which causes the impressions on

the paper strips, is strongly attracted, so long as a current passes through the main battery, and line and relay. If this current ceases, it also ceases in the auxiliary battery, and the dash made by it during the closing is interrupted.

If however subsequently means have been found in Germany by the aid of which the dots and dashes of the Morse writing are no longer represented by pressing on the strips of paper, but by means of black or coloured oil colours on the paper, and therefore the relay can now be dispensed with, yet to its employment in the Morse telegraph the very general use of this telegraph is to be ascribed.

Yet even with the help of the relay, the length of the line which can be used for the circuit of a battery is limited. It is only by the translation invented in Germany, that the sphere of action of the Morse telegraph has become unlimited. Without drawings and special descriptions this arrangement cannot be described in detail so as to be understood. It suffices here to mention what is attained by it. Without translation as already stated the sphere of the Morse telegraph is limited. If the messages had to pass beyond this limit, the telegraphist at the first receiving station had to read the message from the paper strip, and send it forward again by hand over a new circuit. This must be repeated at the end of the second circuit and so forth. Naturally by the frequent readings and sending again of messages, frequent errors arise which in the end often make them quite incomprehensible. The translating arrangement automatically effects the sending on again by the receiving apparatus itself of the dots and dashes which it receives, as short or long currents, the apparatus itself therefore performing the duty of the forwarding telegraphist.

In Germany the Morse system has lately been still further developed as the sending of messages by the hand of the telegraphist has been quite obviated. This results from type being cast like print, which are provided with suitable projections on the upper edge. These types are marked with the letters, which they produce in the Morse alphabet, when they are pushed forward under a small lever, which is intended to replace the hand of the telegraphist. If the types are now brought into a suitable mechanism in correct sequence, it is only necessary with its aid to bring

them quickly under the lever in order to send on the message to the place of address. In this way however more labour is required, as the putting together of the messages and the subsequent sorting of the type, demands more time than the forwarding of the messages by hand, but on the other hand errors are avoided, as the messages can be read over before despatch, and as the writing that arrives is mechanically correct and is therefore always safely legible. This mechanical method of despatch has besides the great advantage, that it can be executed much more quickly than is possible with the hand, and therefore with one wire at disposal, 5 or 6 times as many messages can be sent in the same time. The troublesome work of setting up and sorting of the type, will certainly be considerably simplified at an early date, by the construction of proper setting and sorting machines.

As is seen also in telegraphy, the tendency is overwhelming to replace hand work by the more uniform and quicker machine work.

Simultaneously with Morse, Wheatstone was engaged in England with the improvement and introduction of the electric telegraph. He pursued in this two essentially different lines, since he first considerably improved Fechner's needle telegraph and later constructed alphabetical and printing telegraphs. Wheatstone's needle telegraphs are still largely used in England and some other countries, partly as single needle instruments, partly as double needle telegraphs with two magnetic needles, each of which is in communication with a separate conducting wire. The deflections of the needle are limited to a narrow play by means of ivory stops against which the needles strike, so that an experienced eye can easily and quickly tell by their positions the letters which are communicated.

The great simplicity of this apparatus gave it an extended application in the childhood of telegraphy. But later there has been to a great extent a change from it to the Morse system, for the permanent Morse writing on the paper strips gives greater security for the correct repetition of the despatches, than the transient needle play. Wheatstone himself sought some years later to remove this uncertainty in the reading of despatches by the construction of the alphabetical telegraph. In this the letters of the alphabet are represented on a dial in a circle, similarly to the

figures on the dial of a clock. By a series of short electric currents, which were sent through the conductor, a pointer was directed to that letter to which the attention of the receiver was to be directed. This was effected by means of a toothed wheel fixed to the axle around which the pointer turns, and which has as many teeth, as letters or other signs are to be found on the dial. A small hook gears in the teeth of the toothed wheel, which is fixed to the armature of an electro-magnet. If a current passes through the windings of the electro-magnet, the wheel and with it the pointer is moved a step forward. When the current is interrupted, the armature returns to its original position, passing over the next tooth of the wheel which is arrested by a catch. A second current brings the pointer a second step forward and so forth, each current a step. The forwarding station can therefore place on any desired sign of the dial the pointer of the apparatus of the receiving station by a determined number of short currents which it sends through the line. If the short currents follow at a quick rate until the pointer has reached its goal, and if then a slight pause follows, the receiver easily knows what letter or other sign his correspondent desires to indicate. The production of the necessary number of currents in order to move the pointer forward from the last communicated letter up to the next letter to be communicated, Wheatstone effected by turning a handle round a graduated circle which had the same letters and other characters in similar sequence as in the dial of the receiving apparatus. The handle was insulated from the metal graduated circle by a non-conductor of electricity, such as ivory or wood. Its surface consisted of spaces alternately conducting and insulating, that is covered with ivory. A metal spring was attached to the handle, which passed over these spaces of the graduated circle as it was revolved. If now the sender's graduated circle was in conductive connection with the free pole of a battery connected to earth, and the handle with the line wire, a current occurred in it every time the spring passed a metallic space, and ceased again as it passed an insulated one. If the handle was moved forward from any letter to any other, the pointer of the receiver must move forward to the same, or in other words, handle and pointer must always point to the same letter. Telegraphing therefore simply consisted in the sender of the message placing the handle on all the letters of the message to

be sent, one after another, and the receiver reading off the letters against which the pointer stopped for a moment.

This very simple alphabetical telegraph of Wheatstone was variously altered and improved, already partly by himself, partly by others. By the introduction of clockwork which moved forward the pointer of the receiver, and an arrangement called an escapement in horology, the number of necessary currents to move the pointer from one letter to another, could be reduced to a half, since the attraction of the armature as well as its backward motion moved the pointer one step forward. On the other hand, the Wheatstone handle was quite obviated, as the making and breaking of the current could be made by the electro-magnet itself. In this arrangement which will now be further described, the electro-magnets of the receiving apparatus at one or more stations, were simultaneously inserted in the line. The apparatus formed automatic electro-magnetic machines, the pointer of which always simultaneously traversed the letter dials. Each instrument was provided with keys which were inscribed with the corresponding letters of the dial. If a key was pressed down, then the pointers of all the apparatus in circuit traversed the dial of the dial plate up to the letter the key of which was pressed down, and remained there as long as the key was kept down. The forwarding of messages with this automatic pointer telegraph, is effected by the person wishing to send a despatch, or speak as it is usually called, spelling out the message with the keys of his instrument. The pointers of all the apparatus inserted, all stand still for a moment at the signal given, and thus make it known to the observers.

The printing telegraphs proper are closely connected to the alphabetical telegraph. Wheatstone already connected a printing arrangement with his still very imperfect alphabetical telegraph. The constructors of later alphabetical telegraphs have done this in a different way. It always consists essentially, in rotating instead of the pointer, a disc, on the periphery of which are the usual printing types. By means of mechanism, the description of which must be here omitted, the letter at which the apparatus stops for a minute, is printed on a paper strip which moves forward slightly after the printing to make room for the next letter. The message then appears on the paper strip in ordinary type.

A further improvement of Wheatstone's alphabetical telegraph,

consists in the introduction of magneto-electric currents for moving the pointer forward instead of galvanic battery currents. When the pole of an electro-magnet is brought quickly near the poles of a strong steel magnet, a short electric current is produced in the windings of the electro-magnet during the approach. If the electro-magnet is removed again, a similar current of opposite direction is produced. If now with the handle of the Wheatstone dial telegraph, an electro-magnet is brought into such mechanical connection that by the motion of the handle in passing from one letter to the next its poles approach the poles of a steel magnet and on the next step of the handle recede again from it, as many currents are produced as letter spaces are traversed by the handle. If these currents instead of the battery currents traverse the conductor and the windings of the electro-magnets of the receiving stations in circuit, a means is thereby afforded of keeping the pointer of the latter in step with the handle, as was the case with battery currents.

The previously described alphabetical and printing telegraphs, all effect the motion of the receiver corresponding with that of the sending apparatus, through a series of short currents, of which each separate one, or each pair of opposite currents moves the pointer or printing wheel, one or two steps forward. The Englishman Bain constructed a printing telegraph on another principle. He caused the type discs to revolve by clockwork, which had a very uniform motion. By an electric current which traversed the telegraph wires, these clockworks were simultaneously released and again stopped by breaking the current. If the clockworks went uniformly, the pointers or printers must always rest over the same letter if they had similar positions before being started. Therefore in this instance it is not the number of currents, but their duration which determines the position of the pointers or printers. This apparatus has recently been much improved by the American Hughes and now prints telegraphic messages with extraordinary safety and speed, which appears to promise for it a permanent use along with the Morse writing telegraph system.

Besides the three telegraph systems previously described which have principally come into use, viz. the needle, the writing, the alphabetical, and printing telegraph, many others have been proposed and even brought into use. Thus Vorsselmann de Heer already in 1839 proposed a telegraph based upon the physio-

logical action of the electric current. In this the fingers of the receiver were to be inserted in the telegraphic circuit by touching metallic knobs, which formed the ends of the conductor. Each current which traversed a line, then produced a convulsive movement of the corresponding finger, by which it was known in which conductor an electric current was produced and how long it lasted. In place of alarms, the telegraphist was to have two metallic plates on his body in metallic connection with the line, which conveyed to him the sensible warning to lay his finger on the metal knob for the reception of a message.

As already previously mentioned, Steinheil already connected with his telegraph little bells of different tones by means of which the receiver of a message was able to understand it by sound. Such acoustic telegraphs have been constructed subsequently by others, they could not however keep the field any better than the needle and dial telegraph in comparison with the writing and printing telegraph, which made a permanent record of the messages. On the other hand, such acoustic telegraphs which are not to give full messages but a few determined signals, have found very general use. They are made use of as alarms to draw the attention of the telegraphist to his receiving instrument as electric bells, and especially in Germany to a great extent, as signalling apparatus for railway employés to warn them of the departure of a train from the nearest station. With these gongs on railways, the motion of the heavy hammer which strikes the gong placed on the railway-porter's lodge, is of course not moved directly by the electric current, but by the weight of a clockwork, the release of which is effected by the attraction of a small magnet armature by means of the electric current.

The decomposing or chemical action of the electric current has also been used in the construction of different kinds of telegraph apparatus. As is known, the first form of electric telegraph, Sömmering's, was electro-chemical, as the signals were made visible by the decomposition of water. But besides water the electric current also decomposes many metallic compounds dissolved in water whilst it deposits the metal from it. Thus, by means of the electric current, copper, silver, gold, nickel, and other metals can be laid on the surface of other metals, or on conducting moulds, as happens in galvanic silvering, gilding, and electro-typing.

Amongst other bodies iodide of potassium as well as prussiate of potassium is decomposed by electricity very easily and even with very slight currents. If a strip of paper is saturated with a solution of such a salt, and if it is caused to be drawn in the damp condition under a metal point by means of clockwork, which presses it against a metal piece under the paper strip, then the point leaves on the paper a dark stroke so long as a current passes from the point to the paper. Such an arrangement can also be used instead of the Morse telegraph mechanism for fixing the Morse writing, according to the proposal of the Englishman Bain. The Englishman Bakewell based on this, already in 1847, his electro-chemical copying telegraph. This apparatus excited much attention, as it was able to reproduce the handwriting of the sender of the message, and also representations of pictures. At each of the two places which were connected by means of an insulated wire was placed a metal cylinder. On one the message is written or the picture to be telegraphed is drawn with an insulating lac ink. The cylinder of the other station is covered with a sheet of chemically prepared damp paper. By carefully regulated clockwork both cylinders can be rotated on their axes at exactly the same speed. On the surface of each cylinder a metal point glides, which is connected with the other through an insulated conducting wire. If now the two metal cylinders are conductively connected together by means of a second wire or the earth, and if a galvanic battery is anywhere connected up in the circuit so arranged, then it would be always traversed by a current, and in this way an unbroken line of colour is produced on the paper strip if a short interruption of the current were not brought about by the layer of varnish each time the point passes over a stroke. These passages over the stroke show themselves consequently on the paper as white points in the black line. By a simple arrangement the points after each revolution of the cylinder are shifted a little sideways. A shading of dark lines is therefore formed on the sheet of paper, in which the letters or drawing are seen in the bright colour of the paper. In a similar way the whole cylinder can be covered with lac colour, and the picture in the writing to be transmitted can be etched into the coating. The current will now only circulate when the point touches an etched place, and thus comes into metallic connection with the cylinder. The pic-

ture on the sheet of paper then appears as black points on a white ground.

This copying telegraph of Bakewell's has always attracted public attention to a wonderful degree, owing to its performance at first sight appearing extraordinary. It has frequently been reinvented and much altered, without being essentially improved thereby, and one might with some propriety call it the telegraphic sea serpent, which sets the world in motion from time to time by rising from oblivion only to disappear again without leaving any trace. In fact this system will never attain a great practical importance, even if the mechanical difficulties are fully overcome. The reasons lie partly in properties of the conductors to be discussed later, which render the application of the electro-chemical telegraph very difficult, but principally because the copying of signs adapted for production by the hand, but not for telegraphic communication, requires a much greater number of elementary telegraph signs than a Steinheil's or Morse's sign, which is specially designed for this purpose. By the use of such telegraphic writing signs, which consist of the simplest combinations of the two elementary signs of the Morse alphabet—the dot and dash—one can, therefore, send through a conductor, in the same time, a much larger number of messages than by copying the usual handwriting by Bakewell's copying telegraph, or those of his successors.

This theoretical superiority of those telegraphs which employ the simplest combinations of elementary signs for the formation of telegraphic signals, gives them a permanent superiority over the alphabetical and type printing telegraphs. In order to bring the alphabetical or the type wheel from the first to the last letter of the alphabet at least half as many currents as it contains letters are requisite, as previously explained, therefore, the production of a telegraph signal requires with them a greater average number of currents than with the Morse telegraph. With the latter, therefore, a greater speed of transmission is possible, for the number of currents to be sent through the conductor in a certain time is limited. Both Bain's and also Hughes's printing telegraph, founded on the same principle, form no exception to this, although they only require one reversal of current for the production of a printed letter, and it is all the same as regards the speed of transmission, whether the time for turning the type-wheel is taken up

by a permanent current or by a series of short currents. What is decisive is only the duration of the single current, which is in the position to produce an elementary signal, and, therefore, to move the printing wheel forward a step, and the mean number or the interval of time corresponding to it of such currents which is, on the average, necessary for the production of a telegraph signal. With short telegraph lines, where the cost of laying and maintaining the line does not, as in long lines, greatly exceed the cost of the work of despatching the messages, it is less important to be able to despatch as many messages as possible in a given time through one conducting wire, than to make the work of sending and receiving as small as possible.

Therefore, in all probability, the direction in which telegraphy will further develop must be, for correspondence between distant places and countries, the transmission of the Morse writing by mechanical means, and for correspondence between places lying near together, letter printing will come into general use.

As follows from the above sketch of the gradual development of the idea of the electric telegraph to the instruments now used, it was principally practical difficulties which were first overcome in course of time. The scientific man could easily devise methods and combinations, which made telegraphic correspondence possible, and which also, when tested in a room, proved excellent. But in practice a new troublesome element entered, which upset his plans, viz.: the insulated conductor between the two places to be telegraphically connected.

To be able rightly to estimate the great difficulties which this brought with it, it must be made clear what is a good conductor and to what risks of all kinds it is exposed. The conducting wire must not only exist in unbroken metallic continuation from one end to the other, it must not at any single place in all this length be in good conductive connection with the earth. Such a connection is made through every metallic or damp body which simultaneously touches the wire and the earth, as well as through the moistened surface of a non-conducting body. If, therefore, the wire had been separated by glass, porcelain, or indiarubber from the wooden posts which themselves insulate tolerably well when dry, and which keep it removed from the ground, yet if at any place on the line the rain wetted the surface of the insulator,

it established a conductive connection with the earth through which the electricity could be directly conducted away to the latter instead of passing along the great distance through the apparatus of the distant station. Even in dry weather the conducting leaves of the trees endanger the insulation when driven against the wire by the wind. Every thunder cloud which approaches and passes away at any part of the conductor, every disturbance of the magnetic equilibrium of the earth, as happens especially with auroræ boreales, produces electric currents in the conductor, which disturb the regular action of the apparatus in the same way as its imperfect and variable insulation. Lightning striking the conductor anywhere often destroys whole lengths of it, and with it the apparatus of the neighbouring stations, if they are not protected from its action by good lightning dischargers. If one considers the numerous occurrences of all kinds which threaten destruction to wires, insulators and posts, it often appears wonderful that lines which uninterruptedly encircle half the globe can continue for a long time in undisturbed use.

Consideration and experience have taught us by degrees either to remove these disturbing and destructive influences or to make them harmless. With the bell form of insulator a dry surface for the insulator was always attained, which assured the insulation of the wire even in rainy weather. Thick iron wires, which were used instead of copper ones, resist storm, frost, and destruction by lightning and wantonness better than the previous copper ones. This was also effected by strong posts, which were used in place of the former thin poles. Finally it was learnt how to construct telegraph apparatus so that they performed their functions quite undisturbed and properly with great variations in the strength of the current.

The difficulties of overhead wires just described appeared not unreasonably to the men, who first conceived and applied the idea of the electric telegraph, to be so insurmountably great, that they held it to be much more easily practicable to provide the conducting wires with an insulating covering and then to lay them in the ground. Sömmering wished to cover his twenty-seven wires separately with silk, then to insulate them together from the ground with glass or earthenware pipes. Gauss and Weber, as well as Steinheil, used overhead conductors, yet they resisted dis-

turbing influences of all kinds for only a short time, and during their existence gave rise continually to irregularities in the despatch of messages.

The Americans and English first succeeded in overcoming the difficulties of overhead conductors in some degree. On the continent of Europe it was first sought, on the contrary, to carry out practically the underground system of conductors, for there was greater fear here than in those countries of wanton destruction of the overhead conductors visible and accessible to every one. Jacobi, in St. Petersburg, made extensive experiments with copper wires, which were insulated from the ground by winding them with indiarubber and by glass tubes drawn over them. But it soon became evident, that in this way no complete insulation was obtained, as the dampness of the ground made its way to the wire through the seams of the indiarubber and the joints of the glass tubes and frequently destroyed it. In Prussia a beginning was made with overhead lines, but there was a fear of following it up owing to disturbances frequently occurring. After Jacobi's method had been tried and proved to be unsuitable, the production of safe underground lines was tried in another very promising way. In 1846 a new material, guttapercha, became known, which had many properties, besides the extraordinary insulating property, in common with indiarubber, but differed essentially from it in forming a plastic dough when warmed. The difficulty of forming this dough into a tube closely surrounding the wire without a seam was overcome by a peculiar machine, which laid the soft guttapercha under strong pressure continuously around the wires passing through the machine. The conductors thus prepared were in fact thoroughly insulated, and worked with perfect security on the extensive lines which were laid in so great a hurry in North Germany during the following years. The difficulties of finding faulty places, and numerous others, were fortunately equally overcome; it soon however became apparent that the conductors which were laid in the ground without any other covering were not durable. The guttapercha was gnawed by rats and mice and was altered so essentially by the oxygen of the air, which passed through the loose ground to the wires, that they lost their coherence and their insulating capacity after only a few years.

After this unfavourable experience a return was made, wherever

they could be used, to overhead lines, which in the meantime had been materially improved. Almost all European countries are now covered with a network of iron wires by means of which the electric messenger forwards the thoughts and news of mankind with wonderful speed from place to place from the Atlantic to the Indian and Pacific oceans. The ever increasing telegraphic intercourse naturally makes an ever increasing number of wires necessary, which, in many countries, can only with difficulty be fixed at the distance apart from one another necessary for secure insulation on the posts which already run along all railways and many streets. This difficulty, and the experience that with the number of wires the safety of each is reduced, will probably, in time lead to a return to the forsaken underground system. A better founded experience for this has now been gained through the development of submarine telegraphy. Attempts to bridge telegraphically broad rivers and small arms of the sea by sunken insulated wires had already frequently been made before the Prussian experiments, but always with unfavourable results. Guttapercha pressed on to the wires first gave a means of safe insulation, and made submarine conductors possible. The first of these conductors under water were laid in this way in the spring of 1848, in the harbour of Kiel, for the explosion of submarine mines, which had been laid against the Danish men-of-war, and another passing under the Rhine, at Cologne. Soon afterwards the English took possession of this method for the production of longer submarine cables. The wires pressed round with guttapercha were first closely bound round with tarred hemp, and then with iron wires, whereby they obtained a great strength and were protected from external injury. Such an electric wire rope or cable is laid in the hold of the steamer arranged for laying it just as ropes are coiled. When the ship has arrived at the point of the coast from which the laying is to commence, a so-called shore cable, surrounded with very thick iron wire is first laid through the surf into deep water, which resists destruction better than the thin cable destined for deep water, where the danger is much less. As soon as the end of the shore cable is securely connected with that end of the cable which was last coiled on board the ship, the latter commences its voyage to the other shore. As soon as it has again successfully arrived in shallow water, the end of the deep sea cable is connected with

the shore cable already laid in advance, by which means the telegraphic connection is completed.

This operation, which appears so simple is, however, a very difficult and dangerous undertaking, especially when the depth of water is great. Whilst the ship by the power of its engines hastens to its destination, the cable is passed into the water over a roller placed near the stern, and sinks slowly to the sea bottom behind the ship in consequence of its weight. If the cable were not held back on the ship by some force opposing this weight, it would glide down into the depths at a great velocity along the steep incline formed by the water. To prevent this it must be held back by a brake arrangement with a force as nearly as possible equal to the weight of a piece of cable hanging vertically from the ship to the sea bottom. With great sea depths, which often exceed half a geographical mile, the force is so considerable that there is great danger of rupturing the cable with the least disturbance. If the paying-out machine is unserviceable only for a moment, or if the cable from other causes, through entanglement, or in consequence of the frequently occurring rupture of an armouring wire, is held fixed on the way from the ship to the sea it is usually lost in deep water. But even without rupture the cable may become unserviceable if the insulating covering of the cable has or receives the slightest injury, by which the water obtains access to the conducting wire. One may be assured, by the most careful examination during and after the manufacture, that the insulating covering is free from faults, but the powerful tension to which the cable is submitted during laying now and again brings faults of insulation to light which could not be previously noticed. The cable must, therefore, be subjected to continuous electrical testing during the laying. If a fault in insulation shows itself, the laying must be instantly stopped, and the last laid portion of cable be again drawn back into the ship. From the electrical measurements carried out, the position of the fault must then be determined, and the repair afterwards carried out. If the cable breaks during this operation the previously laid portion is certainly lost, but the portion still on board ship is saved.

The limited space and the scope of this pamphlet will not permit of a more precise description of the arrangements and methods

of testing, by means of which the great uncertainty of the preparation and laying of submarine cables have been so far removed by degrees, that in the course of this year even the great outstanding problem of telegraphy, the laying of a direct telegraph cable between Europe and America, has fortunately been solved.

This telegraphic connection of the west coast of Ireland with the coast of Newfoundland is not only remarkable on account of the faultless preparation and laying of the cable about 300 German miles in length, but also on account of the quite unexpected speed and safety with which the forwarding of messages is carried on through it.

Already in the year 1848 a peculiar property of the underground conductors from Berlin was recognized. This is, that the electric current does not, as in overhead lines, appear simultaneously along its whole length and at the same moment in which the line is connected with the free pole of an electric battery, but that the current begins somewhat later at the further end of the line than at the battery end. The cause of this is, that the wire with the damp earth surrounding its insulating coating forms a Leyden jar in which the electricity accumulates. The electricity passing from the galvanic battery into the underground or submarine cable must, therefore, first be employed to fill with electricity or charge the great Leyden jar which it forms, and only after this is effected can the current commence at the distant end of the line. If the connection of the wire with the galvanic battery is interrupted, then the cause of the charge ceases, and the static electricity collected on the surface of the wire flows through the distant end of the line to earth, by which the jar is again discharged. The current, therefore, not only begins later at the further end of the line but also ceases later. This phenomenon can be almost represented by the pumping of air through a long narrow tube with elastic walls. Near the pump, the tube at each stroke of the pump would be extended by the elastic pressure of the air driven in. This extension would advance to the other open end of the tube in a diminishing measure, and the outflow of air from it would only commence with full force, when the tube had assumed a conical form. When the pump-stroke was completed the tube would return to its normal diameter, and the superfluous air go out from the distant end. Should a second piston stroke begin

before this flow is completed, the air would not come out at the distant end in puffs, but the current would hardly cease, and air would always flow out, although with varying velocity.

The behaviour of electricity in underground lines and submarine cables is similar. If the electric currents by which a message is to be sent follow each other too quickly, an unbroken current will appear at the other end, which certainly exhibits slight variations in its strength, but the duration of the individual currents sent cannot be clearly distinguished, to say nothing of being made continuously visible mechanically. One must, therefore, speak much more slowly on submarine than overhead lines to obtain clear signals. By the use of alternate currents, that is to say alternately positive and negative currents, these disturbing influences have indeed been considerably diminished, and speech through long submarine lines made safer and more rapid, but to remove them completely will never be possible. On the Atlantic cable receiving instruments are now used, which, in principle, entirely agree with those which Gauss and Weber employed. These are mirror galvanometers, *i.e.*, magnetic needles to which small mirrors are fixed. The observer sees in this mirror the image of a small flame, such as Dubois Reymond first used in his lectures for making visible slight nerve and muscle currents. From the jerking backwards and forwards of the image in the mirror, which is effected by the very weak currents sent into the line, the observer must discover the sense of the message.

With overhead lines the charging phenomena which render so difficult the use of long submarine and underground lines are, as already said, hardly noticeable. But even then an overhead line can be considered as a Leyden jar, of which the wire and earth are the coatings, and the air between the wire and earth the insulating glass wall. Overhead wires must, consequently, be charged with electricity before the current can begin at the further end. The loss of time thus necessitated is, however, so small on account of the small capacity of this wire jar, that it does not come into consideration in telegraphing by hand. On the other hand it soon becomes evident with mechanical telegraphy, in which one approaches the limit of the conductibility of the conducting wire. The longer and thinner this is, the smaller is the number of telegraph signals that can be despatched through

it in the same time. On this account also it is not practicable to use too long circuits, and it is more advantageous to insert translating stations if the messages have to traverse considerable distances.

The question of the greatest speed with which a wire can forward messages cannot be altogether answered from the above, since this depends on the time the electric current requires to get to the other end of the line, or as it is improperly expressed, on the velocity of the electricity in the wires, and since this velocity is dependent on the length and section of the wire and its distance from other conductors as well as on the greater or less conductivity of the metal of which it is formed. By calculation it has been found that the actual velocity of electricity is greater than that of light, therefore, over 40,000 German miles a second. But as no wire can be stretched, which has no inductive action, the propagation of the electric action in all telegraphic conductors is much less, especially in submarine wires, in which the inductive action is particularly large. Reliable experiments on its actual magnitude do not yet exist.

As may be seen, science and practice have yet a wide field of labour before them, so to build up telegraphy theoretically and practically, that it may permanently satisfy the daily increasing demands which social life makes on it.

NEW REGULATOR FOR SIEMENS AND HALSKE'S MORSE INKER.*

With the usual old Morse inkers, the clockwork of which is set in motion by a weight, the necessary uniform motion of the paper strip passing out is effected, as is known, in a very simple manner by a fly constantly fixed to the most quickly revolving axle of the clockwork. For apparatus, the clockwork of which is set in motion by a spirally wound spring, in which, therefore, the driving force is not constant, but alters according as the spring is fully

* Journal of the Deutsch. oesterr. Telegraphen Verein, Vol. 13, p. 27. 1866.

wound up, or already more run down. Messrs. Siemens and Halske have already previously constructed a movable fly, which is described and illustrated in Vol. IX. of this journal.*

In both cases, however, only a previously determined mean velocity of the paper band was maintained nearly uniform, dependent on the conditions of the construction, the dimensions of the vanes, and the amount of the moving force; considerably quicker or slower delivery of the paper could only be obtained somehow by an alteration of the moving power, by a change in the size of the vanes, &c. For the usual Morse apparatus, which have to receive signals sent by the telegraphist of the other station by hand with the key, there appeared in the meantime no pressing necessity to be able to change at will the speed of the paper being delivered, if with one apparatus the speed with which the paper runs out is somewhat greater than with another, or if one employé telegraphs somewhat more slowly than another, nothing else happens than that the writing at one time comes out somewhat more widely apart, at another somewhat more closely together, without becoming illegible.

But the conditions are different for Morse inkers, which are designed to receive the writing of Siemens and Halske's quick type writers. Here the speed with which the type carrier glides under the contact lever can fluctuate between much wider limits, and the speed of the running-out paper at the receiving apparatus of the other station must at least in some measure be adjusted to the actual speed for the writing to be legible; it must, however, always be much greater than with the usual apparatus. Besides it always happens with the lines supplied with these apparatus, that partly through the arrangement of the correspondence, partly through the occurrence of some irregularities or disturbances, remarks relating to the business must be telegraphed by key. For this correspondence the speed with which the paper band of the quick Morse writer passes out is much too great; an ordinary Morse instrument must, therefore, be set up near the latter, which can be inserted in the line as required in place of the other, or all such service remarks must be telegraphed by another line, which, however, is very disturbing for the business of the second line.

For such quick writing Morse instruments, therefore, the

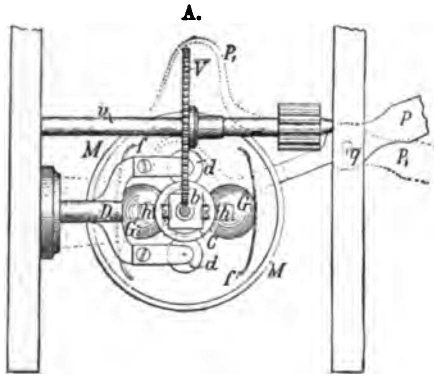
* P. 188, *ante*.

problem arose so to construct the speed-regulator that not only the speed at which the paper band runs out shall be uniform—and particularly in a much higher degree than is necessary with the usual Morse apparatus, but also that this speed can be altered within wide limits by an easily and quickly set mechanism. This problem has been solved by Messrs. Siemens and Halske by the arrangement shown in Fig. 109, in top, and in 109B in side view.

The idea of the wind vanes is quite abandoned in this; their place has been taken by two balls, fixed by means of thin elastic rods to a quickly revolving axle, which under the influence of

Fig. 109.

A.

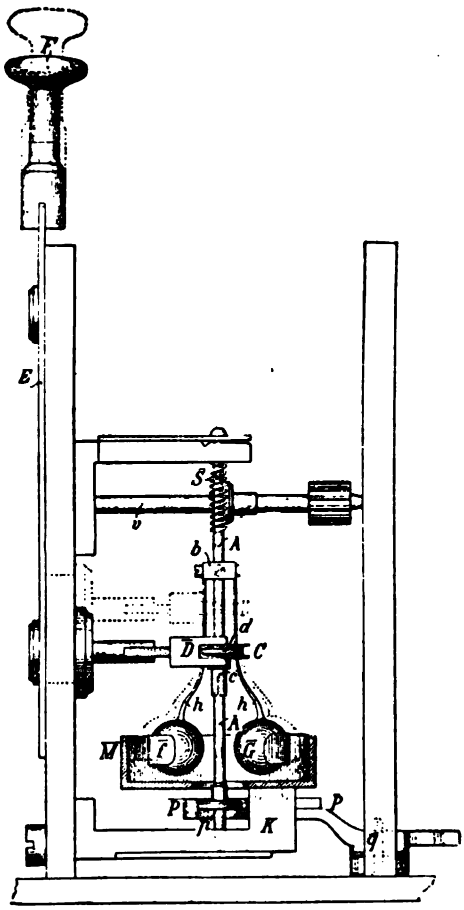


rotation, in consequence of centrifugal force, fly away from one another, and press with more or less friction (dependent on the velocity) against the inner side of a fixed cylindrical case surrounding them. *vv* is the last, quickest revolving axle of the clockwork, the toothed wheel V fixed to it gears into an endless screw S, situated at the upper end of the vertical governor spindle AA, and sets the spindle in rapid revolution. Below the worm of the screw, the little block *b* is screwed on to the axle of the spindle, to which two elastic blades are fastened, carrying the balls GG. On the outer sides of the balls are the springs *ff*; when the balls fly out these touch on the cylindrical inner side of the flat open box MM, which is firmly fixed to the metal piece K, which also carries the under bearing of the regulator spindle. The bottom of the box is provided with a central circular hole of such width, that not

only the spindle itself but also the friction disc p fixed to its under side, can freely pass through. The bearing of the lever PP,

Fig. 109.

B.



turning around the pin q—the shape of which is clearly seen in the dotted portion P_1P_1—against this friction disc effects in the ordinary way the stoppage of the clockwork and the paper strip.

By means of the construction described above the object in

view would not be attained. In order to be able to alter at pleasure the resulting uniform speed of running, there must be a means of altering the friction of the springs *ff*, in the box MM, also independently of the speed of rotation. The piece C effects this, which is held by the fork D, and can be adjusted in position by it. This is a small metal drum bored centrally in the axis, and to avoid any shaking, lengthened by a split bush, which is loosely borne on the cylindrical portion of the regulator spindle AA, and can be easily pushed along it. This is drilled through parallel to the axis at two diametrically opposite places, with two openings of rectangular section through which the blades *hh* pass ; in the edge of the drum a broad and deep channel is turned. In this channel, at two diametrically opposite places, the friction rollers *dd* gear in the prongs of the fork D ; they, therefore, maintain the drum C at a certain height, without opposing its rotation.

The fork D is for its part fixed on the slide E, movable in a guide in a vertical direction by means of the knob F, and it can, therefore, be raised or lowered at will by means of the knob F. With such an alteration of the position of D the roller C follows, and as the blades *h* carrying the balls can only separate from one another below this roller, the length of the parts of the blades *h* coming into action can be altered by moving D, and thereby also the amount of friction of the springs *f* on the inner metal surface of M. If D is raised quite up, the balls fly wide apart, press the springs *ff* with great force against the brake M, and the motion is reduced so powerfully that the paper does not pass out more quickly than with the usual Morse, and that one can without difficulty receive the writing sent by hand. If, on the contrary, D is pushed quite down, the length of the blades *h* is shortened, so that the springs hardly at all touch the surface M, the retardation of the motion is exceedingly small, and the paper runs off with a speed as great as is necessary only for the quick writer. For the intermediate positions of D any desired velocity for running off the paper can be obtained between these limits.

THE PNEUMATIC DISPATCH OF MESSAGES BETWEEN THE CENTRAL TELEGRAPH STATION IN BERLIN AND THE EXCHANGE BUILDINGS THERE.*

Preface.—At the desire of the head telegraph authorities Messrs. Siemens and Halske, in the year 1865, brought forward a detailed plan of a pneumatic connection between the Exchange buildings and the Central Telegraph station in Berlin, which was accepted, and entrusted to the firm for execution. The scheme began with a complete explanation of the theoretical bases of the arrangement, supported by experiments, which were made for this purpose. This theoretical portion is already published at p. 207 of the first volume of this collection, under the title "On the law of the motion of gases in tubes." The following is the technical description of the installation given in the official telegraph journal, by the editor, Dr. Brix, in the form in which it was carried out by Messrs. Siemens and Halske.

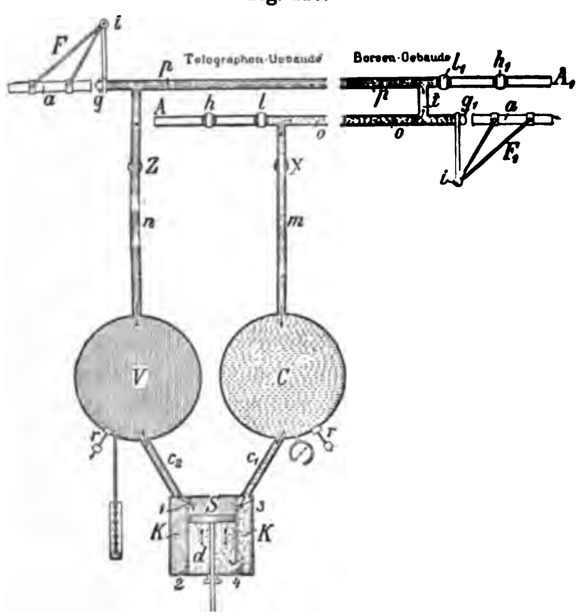
Between the new telegraph buildings in Französische Street and the Exchange buildings in Burg Street there are laid close together two lines of drawn wrought iron tubes *o* and *p* (Fig. 110) of 2¼ inches internal diameter, from 2 to 3 feet below the pavement. In the Exchange buildings they are connected at a few feet from their ends by means of a connecting tube *t*, whilst the ends themselves are closed by means of stop-cocks or valves.

In the telegraph buildings the pipe-line *o* communicates with a reservoir C of compressed air through a tube *m*, branching off about 5 feet from its end, and capable of being closed by the cock X; the pipe-line *p*, on the contrary, communicates through the tube *n*, branching off about 1 foot from its end, and provided with a cock Z, with another reservoir V, out of which the air has been pumped. The ends of the tubes are also closed here; the end of the pipe-line *o* by the cocks *l* and *h*; the end of the pipe-line *p* by the flap valve *g*, which latter has subsequently been replaced by a cock. Between the two reservoirs V and C is the air pump (cylinder blower) which draws the air from the reservoir

* Journal of the Deutsch. oesterr. Telegraphen Verein, Vol. 13, p. 90.

V and forces it into the reservoir C. For driving this pump a steam engine of 10 to 12 horse-power, with horizontal cylinders, has been put down in the vaults of the telegraph station, the steam piston rod of which is extended and carries directly the air pump plunger. If the air pump plunger moves in the direction of the arrows the valves 1 and 4 rise ; the air is compressed by the plunger towards *d*, driven through the open valve 4 into the

Fig. 110.



chamber K, and from this through the connecting tube O into the reservoir G, whilst into the vacuum behind the plunger air streams out from the reservoir V through the valve 1. On the return of the plunger the valves 1 and 4 close, whilst on the contrary the valves 2 and 3 open ; the air in the pump barrel in front of the plunger is, therefore, driven by the valve 3 again into the reservoir C, whilst the pump now exhausts from the reservoir V, through the valve 2.

Therefore, both on the forward as well as the back stroke of the plunger the air in the reservoir V is rarefied, and compressed in

the reservoir C. Both reservoirs, however, communicate through the pipe-lines *o* and *p* and the connecting tube *t*; the air from V compressed into the reservoir C will, therefore, always stream back again in this way into the reservoir V, and it consequently follows, that when the pump works a continual current of air passes from C through the tube *o* to the Exchange, here through the connecting tube *t* to the tube *p*, and through this back again to the reservoir V.

If a message-carrier, *i.e.*, a cylindrical box provided with wheels arranged to receive the rolled up copy of the messages, which will be described more closely later on, fitting into the tube like a plunger, is brought into any part of the tube system, it is caught by the current of air and carried away with it to the end of the respective circuit. In this way the message-carrier can be forwarded through the tube *o* from the telegraph station to the Exchange, and through the tube *p* from the Exchange to the telegraph station.

In order to control the compression of the air in the reservoir C, and its rarefaction in V, both reservoirs are supplied with suitably constructed manometers. Besides C is fitted with a safety valve *rr* of 2 inches diameter, opening outwards, and with one opening inwards, by the loading of which the pressure of the air in the reservoir is kept within certain limits, and the velocity of the carrier can thus be regulated. If the load on this valve is once tested for a desired velocity of the carrier, this load should not be arbitrarily altered, as thereby naturally an altered velocity of the carrier would ensue.

In the telegraph station the end A of the pipe-line *o*, reaching beyond the branching-off point of the connecting tube *m*, serves for introducing the message-carriers. This piece of tube, as already mentioned, is provided with two cocks *l* and *h*, the bore of which exactly agrees with the bore of the tube, so that when opened they pass the message-carriers, and their distance from one another is somewhat greater than the length of the message-carrier, so that there is sufficient room for one between them in the tube; as a rule these cocks are closed. The outer end of the tube beyond *h* to A is split longitudinally and bent up to a trough opening above. In this trough the message-carrier to be sent off is placed, and as the tubes from A have some fall to the circuit *o* lying in

the ground, it rolls downwards in front of the still closed cock *h*. This cock is now opened : the message-carrier rolls through and up to the cock *l*, and when finally the cock *h* is again closed and the cock *l* opened, the carrier also passes through this cock and rolls into the underground tube *o*, and as soon as it has thereby passed the position of the mouth of the tube *m* it is caught by the current of air, and carried through the tube to the Exchange station. Arrived here, it does not enter into the narrow connecting tube *t*, but takes its way in a direct line through the extension of the tube *o*, at the end of it, in consequence of the velocity acquired strikes the flaps of the valve *g* and passes into the tube *a*, in front of the catcher F, from which it can finally be taken out. The sending of messages from the Exchange to the telegraph station takes place in a similar way through the other tube circuit *p*, which for this purpose has at the end in the Exchange station the cocks l_1 and h_1, as well as the open trough A_1, in the station in the telegraph building, on the other hand, the stop valve *g*, together with the catcher F.

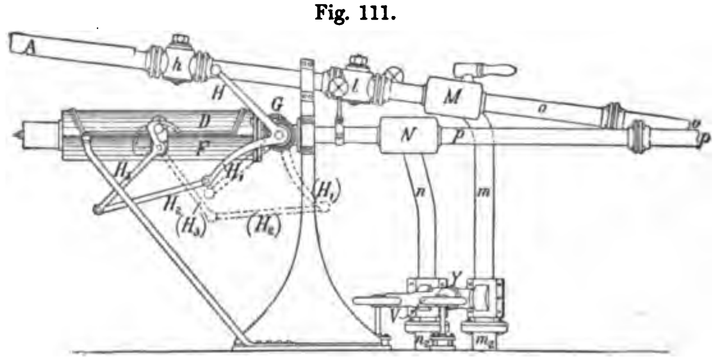
The catcher F consisted, in its original construction, which has since been abandoned, of a tube about 2 feet in length, closed at one end, and somewhat wider than the tube *o*. Forming a continuation of the end of the tube it presented its open end to the valve *g* and its back end was filled to the bottom with an india-rubber buffer ; this turned on two arms around the vertical axis *i*, but was pressed with its open end against *g*, by a spiral spring coiled over this axis. The impulse of the message-carrier passing through the opened valve *g* into the tube *a* causes this tube to turn round the axis *i*, and thus strains the spiral springs, until its resistance balances the momentum of the carrier. A detent arrangement prevents the back movement of the catcher ; only when the carrier has been taken out the catch is released by a lever, whereupon the catcher again resumes its old position, opposite the end of the tube.

A double flap-valve *g* was, in fact, indispensable only at the end of the circuit *p* in the station of the telegraph building, and it was kept closed here by the surplus external atmospheric pressure, and after the passage of the message-carrier again closed. At the Exchange station such a valve was certainly not necessary, as here —in the middle of the tube circuit—the pressure of the air in the

tube is the same as outside, so that it does no harm if the tube here communicates with the outer air. For the sake of safety such a valve was also fitted here, the flaps of which had, however, to be pressed by springs against the valve seat.

The construction of the catcher gave most of the trouble after the installation had been first set to work. The velocity with which the message-carrier arrived at the end station was so great, even with the slowest motion of the steam engine, that by its concussion accidents happened frequently, now with the carrier, now with the catcher, and especially with the spring;

Fig. 111.



but if the velocity of delivery was further reduced it frequently happened that the message-carrier coming from the Exchange on its arrival at the telegraph building was incapable of moving the valve g powerfully enough, and was then caught and fixed by its clasps shutting quickly. To this part of the arrangement, after many alterations of the original idea, the form has finally been given which is shown in Fig. 111.

In Fig. 111 the present arrangement of the station in the vaults of the telegraph station is shown in 1-24th of its actual size. The steam engine together with the air-pump and the reservoirs V and C are placed in a neighbouring subterranean chamber. The connecting pipes of these reservoirs with the tube circuit are led under the floor down to the supports m_2 and n_2 and rise from here to the respective tubes. In the horizontal parts lying under the floor each of these tubes has a separate valve, which is open in normal work; by turning the wheels V, these valves can be closed.

Somewhat above the supports m_2 n_2 the cock Y is inserted between the tubes *m* and *n*, which is always closed in normal work, but in case of necessity it forms a second connection between the two tubes. Near to the forwarding tubes *o* and *p* are found, lastly, separate cocks in the tubes *m* and *n*, which are always open in normal work. The use of these cocks and valves will be learnt later.

The connecting tubes *m* and *n* are not connected directly with the tubes *o* and *p*, because the message-carriers might strike against or become fixed in the apertures thus produced; they open, on the contrary, into the somewhat wider sleeves M and N, which surround, air-tight, the tubes *o* and *p*, here bored with very fine holes.

The action of the cocks *l* and *h* and the trough A is already described above; its construction contains nothing unusual, and is clear enough from Fig. 111, without further explanation. It need only be mentioned, that by means of simple mechanism, on opening the cock *l*, a rod which bears a disc covered with coloured paper rises, and on closing this cock sinks again, and then is quite concealed by the tube *o* from the eye of the operator. It is thus possible for the operators engaged on the work to discover from a distance, at the first view, whether the cock *l* is open or closed. Although it is theoretically of no importance to let two carriers follow each other at short intervals, so that both move simultaneously in the tube, yet for the sake of greater safety the working is up to the present so arranged that only one message-carrier is at the same time in the tube, so that no carrier is despatched earlier than the arrival of its predecessor at the further station has been signalled back, and to prevent this rule being broken accidentally it is arranged that the cock *l* must remain open until the arrival of the carrier is signalled from the further station. For such signals and for other necessary service correspondence a multiple cored cable is laid simultaneously with the tube circuit, the conductors of which are connected to a Morse key and relay in the usual manner, which by striking a gong gives audible sounds. As soon as the cock *l* is opened for the despatch of a message-carrier the further station is warned by pressing the key down three times; he notifies by a single bell stroke, when the carrier has arrived there, and on hearing this return signal the cock *l* at the sending station is

closed and the apparatus is now ready for sending another carrier.

The message-catcher at the arrival end of the tube *p*, as already stated and shown in Fig. 111, has a contrivance quite different from the original one. In place of the flap valve *g* a cock G is provided, the cone of which possesses a bore corresponding to the diameter of the tube circuit, which allows the passage of the message-carrier when the cock is opened. Immediately connected to the flange of this cock is a square cast iron box, hermetically closed by a cover D, movable on hinges; the inner walls of this box, as well as the cover D, are provided with stiff brushes, which gradually become narrower towards the back. The open space remaining between these brushes is considerably less than the outer diameter of the message-carrier, so that this can only penetrate into the box by bending down the brushes, and by the friction thus produced is brought to a standstill. The further end of the box is besides fitted with an indiarubber buffer.

When the cock G is open and the cover D closed the space in the catcher box communicates with the vacuum reservoir V, and the cover is kept closed by the extra pressure of the atmosphere. For greater safety the handle H of the cock is so connected with the revolvable lever H_3 by means of a jointed lever arrangement that when the cock is opened this lies with its upper hooked end over the knob of the cover D, and holds this down hard; when the cock G is closed it leaves the knob free. The plug of the cock has, moreover, besides the passages already mentioned, a side passage, which puts the space in the receiving box into communication with the outer air as soon as the cock is closed to the circuit pipe. The cover D can therefore be opened without difficulty after the closing of the cock G. In order to avoid an accidental turning of the cock G, a spring is arranged on its cover, the nose of which falls into a notch in the plug of the cock and holds it fast; this spring must first be raised somewhat with the left hand before the cock G can be turned by means of the hand lever.

Near the cock G a rod passes downward to the tube *p*, which bears a similar disc to that already described as connected with the cock *l*. As soon as the signal arrives from the distant station that a letter-carrier has been sent, this disc is raised, and the cock G opened, if perchance closed. After the arrival of the

message-carrier, which is accompanied by a very audible noise, that disc is pressed down, the cock G closed, the catcher-box opened, and the carrier that has arrived taken out.

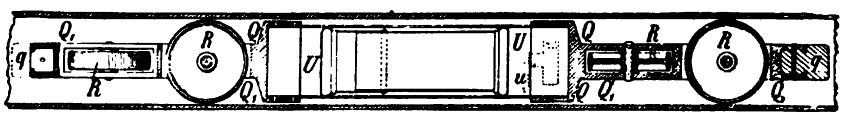
The station in the Exchange building has an exactly similar arrangement; but it does not have the air-pump and the reservoirs V and C, nor the connecting tubes *m* and *n*, with their different cocks and valves, which are replaced by a short tube *t*, connecting the covering pieces M and N directly together.

Both the end stations of the pneumatic tube-post are placed in the vaults of the building in question. In the Exchange building the connection of the pneumatic station with the offices in the ground floor is effected by means of an endless leather belt, carried over pulleys which can be turned by a handle, and suitably guided and stretched by a system of rollers, and which has pockets at two places for the receipt of messages. In the telegraph building the pneumatic station has only to communicate with the instrument room, three floors above; this takes place by means of a pneumatic tube connection, very similar to that described at page 1 of this Journal for 1864, which connects the instrument room with the arrival and despatch rooms, with the sole difference that the current of air required for that purpose is not provided by a bellows, but by the delivery of compressed air from the reservoir C, which for this purpose is in connection through a tube provided with a cock with the lower end of the pneumatic communicating tube. Closed iron boxes are used as cases for the messages to be sent, which are furnished at both ends with thick felt discs of somewhat greater diameter. These cases have sufficient room in their somewhat wider receptacle for the message-carriers, so that it is not necessary to remove the messages from the cases; but the latter can be forwarded in them from the telegraph building to the Exchange, or despatched on the contrary from the Exchange direct to the instrument-room in the telegraph building.

Let us now refer to the message-carriers: such a one is shown in fig. 112, $\frac{4}{15}$ths of the actual size. The middle portion of the carrier arranged for the receipt of the message-case is formed of a drawn brass tube, U, $7\frac{5}{8}$ inches long, $1\frac{3}{4}$ inches outer diameter, and fully $\frac{1}{32}$ inch thick. On its ends iron caps Q Q, are fixed, on the bottom portions of which solid iron projections Q_1 Q_1, are mounted, which are each provided with suitable slots for two wheels

R R, and carry the axles of these wheels. The ends of these prolongations have in the axis slightly conical borings $q\,q$, in which indiarubber corks, serving as buffers, are inserted half-way, and are fastened with a pin. One of the iron caps Q Q, is firmly riveted to the tube U ; the other serving as a cover to the box, is merely pushed over the tube on which it fits exactly, and fixed to it by a double bayonet-joint, at two diametrically opposite parts, as the figure shows. As, however, owing to the motion of the carrier in the tube, the cover may turn somewhat of itself, and consequently can fall quite off, and thus cause the carriage to get fixed in the tube, a little spring u, is also fixed to the tube U, which engages, by means of a nose in the slit of the cap, as soon as it has been turned in closing, and so makes impossible an accidental turning back. When the boxes are to be opened the spring

Fig. 112.



must first be pressed back somewhat, and then the caps can be turned.

This closing device has already been much altered : we have described the latest construction. In the old arrangements the cover also was soldered to a brass tube four or five inches long, which fits exactly into the tube U, into which it is slipped. The closing was effected sometimes by a bayonet-joint, at another by a snap-spring.

The wheels are solid, of hardened steel, and run on smoothly polished axles, which are firmly riveted in the iron pieces Q_1 Q_1. These four axles do not lie all in one plane, but are displaced alternately by 90° from the next one (naturally, however, they all stand vertical with respect to the middle line of the carrier), so that the first and third wheel, counting from the left, turn in one plane, and the second and fourth in another, which stands at right angles to the first. It is easily seen that with this construction the carrier always rolls on the wheels, let it turn as it will. The tube U and the caps Q Q, are protected from rubbing

the walls of the conducting tube, as the steel wheels have a somewhat greater diameter than the end caps Q Q. At the same time the diameter of the wheels is about $1\frac{1}{2}$ mm. less than the inner diameter of the conducting tubes. Although a loss of air, which escapes between the carrier and the tube, and therefore a loss of energy is thus caused, yet this is necessary, because the carriers could easily become jammed, especially at the places where two pieces of tube join together, if these do not lie exactly in the same straight line, or at places where the tube is accidentally somewhat narrow, or where it is pressed somewhat oval.

The tube circuits, as already stated, are made of drawn wrought iron tubing of $2\frac{1}{4}$ English inches internal diameter, and laid two to four feet below the pavement. For connecting the several ends cast iron flanges are used, each with four screw bolts made tight with an indiarubber ring covered with varnish placed between them. To secure exactly central communication of the tubes, and to avoid all jutting-out corners inside the tube circuit, at such spots a small projection is turned up outside on one of the respective pieces of tubing. On the other one a corresponding piece is taken out on the inside, so that the first enters somewhat into the other. The individual pipes have a length of 15 feet.

The circuit tubes descend from the station in the telegraph building tolerably quickly, and then run in an almost horizontal position through the Oberwall Street on its west side, and passing the Artillery House to the corner of the Royal Ministry of Finance, then through the street "Hinter dem Giesshause," as far as the little iron bridge at the principal Custom House, here they pass over the left arm of the Spree in a curve, rising above the rail of the bridge, and then run along the new Museum, and over the massive Friedrich's Bridge, where they lie under the pavement up to the corner of Hercules Brücken Street, and finally end with a pretty sharp curve in the pneumatic station of the Exchange, lying in the new Friedrich Street. The total length of each of the two tube circuits amounts to 2835 feet.* Along the greatest portion of its way the tube is laid in a straight line, or very slightly curved lines; sharp curves occur only at four places, namely, in

* When the pneumatic circuit in Berlin was first discussed it was intended to form a connection of that kind between the telegraph building and the Potsdam railway station; the length of 13,000 feet given at p. 209 of the first volume of this collection had reference to this project.

passing up from the telegraph building across Französische Street to the Oberwall Street, behind the Giesshaus, in passing over the iron bridge, and at the entrance into the Exchange. It was necessary to treat only the last two curves as actual curves of 40 feet radius, and to employ correspondingly bent pieces of tubing. So great a radius could be given to all the other curves that they could be constructed without disadvantage out of straight pieces of tube. The construction of the carrier would have permitted of curves of 20 feet radius.

The passage of the pneumatic tubes over the iron bridge by the chief Custom House was effected in a curve by the side of the bridge rail on the down stream side. This curve had, however, to rise at least as high in the middle as the bridge-flaps when drawn up, so that the passage of ships, even at the highest tide, at which these can still pass the bridge, should be in no way hindered.

As it was foreseen that water would after a time collect in the tubes, either from condensation of the damp air passing through, or in other ways, consideration was given to remove this disadvantage in the project, by laying collectors in the lowest portion of the line, in which the water could collect, and from which it could be easily withdrawn. However, only a very slight collection of water has taken place, and that specially in the tube *o*, connected with the compression reservoir C.

Rust only forms very slightly in the tubes. In order to clear the conductor from this, formerly a cylindrical brush, the outer diameter of which slightly exceeded the internal diameter of the tube, the back end of which was provided with a leather ruffle, was put in place of the carrier, and forced through with great force. With the very small quantity of rust, however, this operation is now only seldom required.

It has several times happened, especially at first after starting the regular work, when the necessary experience as regards the proportion of pressure to be brought into use had not yet been gained, and the construction of the carriers, &c., still suffered from many imperfections, that the message-carriers stuck in the tube. In such cases it is not advisable to drive the carrier further by increase of pressure; on the contrary, if it was jammed the harm would be increased. It is therefore preferred, by altering the

direction of the current of air, to push the carrier back to the starting point, which with the actual arrangement is most easily carried out. For this purpose the separating valve V, and the separating cock of the tube *m* are closed, the cocks *l*, *h*, and Y, however, opened; then the compressed air from C flows through the cock Y to the circuit *p*, traverses the connecting tube *t* in the Exchange to the circuit *o*, and back through this. Or the beginning of the tube *o* might be put in connection with the vacuum reservoir V, by closing the valve V and the separating cock of the tube *n*, and opening the cocks *l* and Y; but the cock *h* would be easily damaged in this way by the impact of the returning carrier, also it would be very difficult to close the cock *l* just at the right time, so that the carrier does not roll back into the tube.

If all these attempts are without success—fortunately a very unlikely circumstance—then, of course, nothing else remains than to take up the tube circuit. For that purpose, however, the place where the carrier is fixed must be approximately known; this was sought to be ascertained in one of the two cases of that kind which have as yet occurred, in the following way:—The above mentioned brush, provided with a leather frill, and, therefore, closing the tube water-tight, was brought into the end of the tube circuit, and this, after closing of the cock leading to the reservoir, was connected with the water-pipe of the building through a water-meter. The water passed into the tube as it shoved the brush in front of it until this had reached the fixed carrier. From the quantity of water passed into the tube, as the interior diameter of the tube is well known, the distance from the end in question to the closing stopper can be calculated. The result of this trial agreed within a few feet with that afterwards found.

Such disturbances of the pneumatic arrangement were, as already stated, only frequent at first after the opening of the working, later they occurred only very seldom. In the last few months only one—a very important disturbance—took place, which was brought about through workmen who were engaged on an alteration of the gas and water-pipes, having injured our tubes from carelessness. The tube in question had, therefore, to be cut out and replaced by a new one. The occasion thus served to prove that during the eight months' use, the tube circuit had not

suffered; the piece cut out did not show the slightest traces of wearing through the wheels of the message-carrier.

When the arrangement was first planned, the minimum velocity of despatch contemplated was that the message-carriers should occupy about three minutes to travel the distance between the telegraph building and the Exchange. In practice it was found that there was no difficulty whatever in reaching that minimum time of forwarding. It was even considerably exceeded—the carriers traversed the distance in the first trials in less than one minute—and it appeared, that the greatest difficulty was rather to reduce the velocity to such an amount that the carriers and catching arrangements might not be too much in danger of injury by frequent shocks, *i.e.*, a duration of travel of about one and a half minutes.

It follows, naturally, that the message-carriers require, with a given difference of pressure, more time for the journey from the telegraph building to the Exchange in the tube *o*, than for the return to the telegraph building in the tube *p*. For as the velocity of the current of air, as follows from the theoretical explanation given above, always increases from the reservoir C through the tube circuit up to the reservoir V, the mean velocity in the tube *p* must be considerably greater than in tube *o*. The difference between the times of despatch is not inconsiderable; in an experiment made for the purpose in which the excess pressure in reservoir C and the exhaustion in reservoir V were alike—namely, 9 inches of mercury—the time of passage of a carrier to the Exchange was 95 seconds, and from the Exchange to the telegraph building, 70 seconds. This agrees exceedingly well with Dr. Siemens' formula, according to which the mean velocities in the tubes *o* and *p* vary in the cases in question, as 69 : 95 from which the ratio of the time of dispatch is as 95 : 69, instead of 95 : 70 as in the experiment. With equality of the pressure and exhaustion in the reservoirs C and V, therefore, if even the difference of pressure is taken as slight as the safety of the despatch to the Exchange permits, the carriers returning thence to the telegraph building will arrive with a velocity injurious to the preservation of the material. To reduce this difficulty, as far as possible, one now uses for the valve of the vacuum reservoir a less load than for the other, so that there exists in reservoir C a pressure of 7 pounds on

the square inch, or 14 inches of mercury, but in reservoir V a vacuum of only 6 inches of mercury. Naturally the valve of V then draws some air constantly, whilst at the Exchange station air passes out with each opening of the cock, because the point where the tension in the tube system is equal to the external atmospheric pressure is now no longer at *t*, but at a point some distance along the tube *p*.

The time of passage of a carrier is, in consequence of this, now on the average :—

In the direction to the Exchange, 1′ 30″,
„ from „ 1′ 20″.

The velocity, thus diminished, of the message-carriers arriving in the telegraph building gives rise to no apprehension; that the time of despatch in the tube *p* is always less than in tube *o*, moreover, is favourable under the existing circumstances, as more despatches are always being sent from the Exchange to the telegraph building than in the opposite direction.

With the above-mentioned relations of pressure there has been no difficulty in despatching in both directions 80 message-carriers per hour; each carrier can carry twenty despatches rolled together, so that by the pneumatic conductor 1,600 messages can be sent both ways in an hour. This performance considerably exceeds the requirements as they now exist, even in the busiest times: in the whole day mostly only 500 to 600, and as a maximum once 800 messages had to be sent by this means.

SIEMENS & HALSKE'S ELECTRICAL WATER LEVEL INDICATOR.*

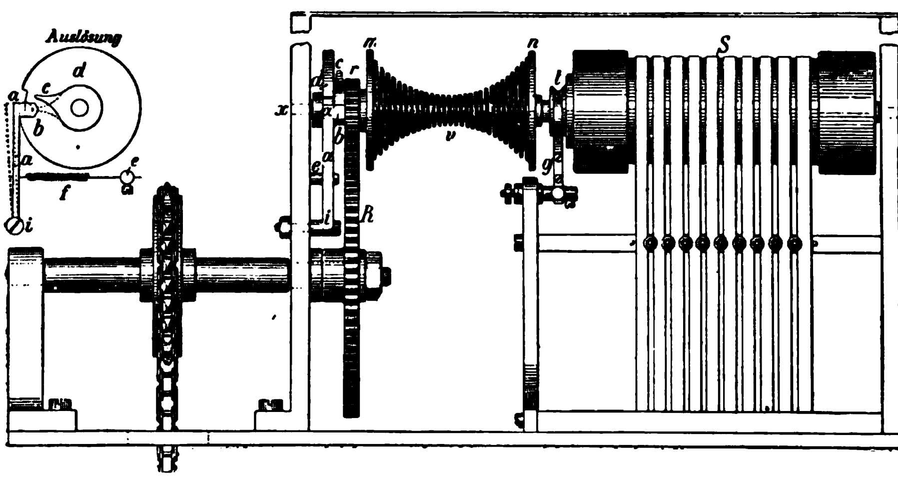
The electrical water level indicator consists essentially of the current generator, the indicating apparatus and the conductor.

The current generator is a magneto-electric inductor consisting of 10 pairs of steel plates as the side view in Fig. 113 shows. The

* Journal of the Deutsch-Oesterr. Telegr. Verein, Vol. XIII., p. 185. 1866.

armature axle *x* of the inductor carries the disc *n* firmly fixed to it, to the surface of which one end of a strong spiral spring *v* is screwed. The other end of the spiral is fixed in the same way to the disc *m*. This is loose on the axle *x* and turns round it together with the toothed wheel *r* and the steel thumb piece *c*. Further there is fixed firmly on the axle *x* the steel disc *d*, which has a notch on its periphery, into which the projection *a* of the lever *a* is drawn by a spiral spring *f*. Besides the projection *a* the lever *a* has also a nosepiece *b* which with each revolution of the

Fig. 113.

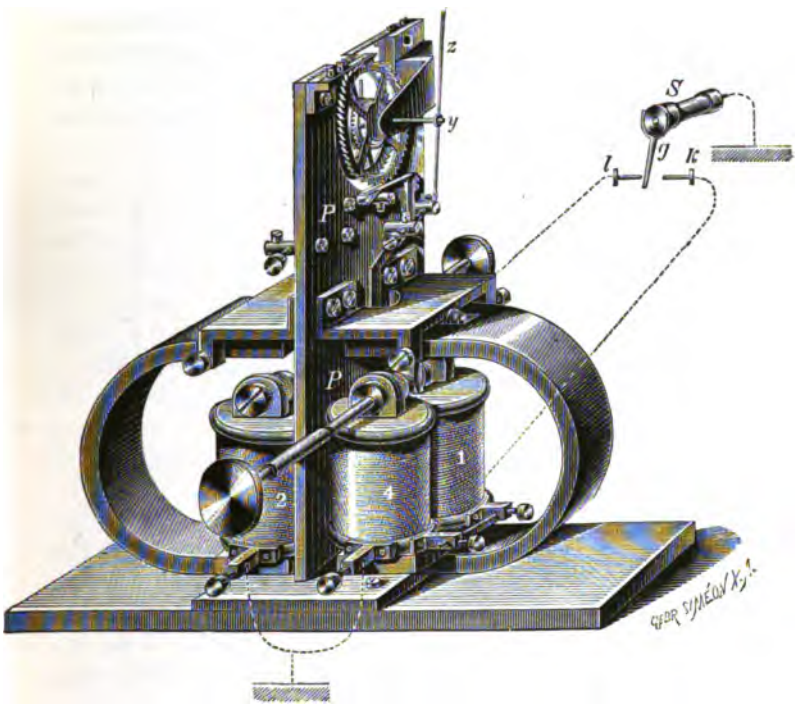


wheel *r*, and therefore also of the thumb piece *c*, moves the lever *a* so much sideways, that *a* quits the notch of the disc *d* and this can turn round unimpeded. If the wheel *r* is turned in one or other direction, the spiral spring is each time strained thereby and tends to turn the axle *x* and therefore also the armature and the steel disc *d*. This is however prevented as long as the projection *a* is in the notch of the disc *d*.

It is only after the wheel *r*, together with the thumb piece *c* and the disc *m*, has turned once round, and has thus stretched *v* by one full revolution, that the thumb piece *c* raises the projection *a* from the disc *d* by means of the nose *b*. As soon as this occurs, the force of the spring *v* comes into operation and drives the

armature of the magneto-inductor once round; the projection *a* then again falls into the notch of the disc *d*, whereby the armature is again stopped until a full revolution of the thumb piece *c* again releases it, and brings about a new revolution. These revolutions take place in one or other direction, according as the spiral spring

Fig. 114.



is turned forward or backward from its position of rest by the revolution of the wheel.

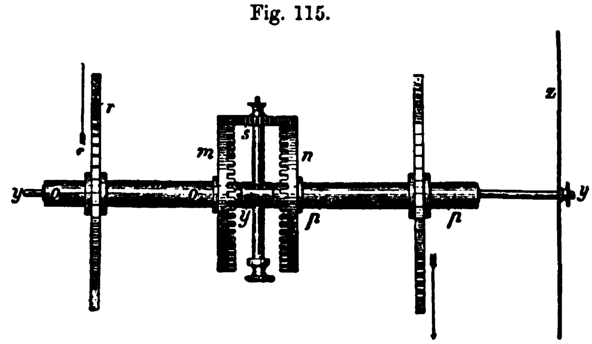
By the one revolution of the armature there are generated in the windings of the conductor, two currents of opposite direction immediately following one another. These currents are used to set in motion a magnet pointer at the other station. One end of the convolutions of the armature is connected with the frame of the apparatus and thereby with the earth, the other however is led to the insulated disc *t*, round which the steel lever *g* is placed.

This lever g is pressed against the disc t by the tension of the screws on it and when the armature is turned, is taken with it in one or other direction up to the contact screws k or l (Fig. 114). These screws are insulated, and each is in connection with a conductor leading to the water level pointer.

There the current circulates round one of the two electro-magnets of the pointer and then goes to earth as is seen in Fig. 114.

The wheel r receives its motion from the wheel R, which, on its side is again moved by being connected with a float on the level of the water through a jointed chain, which is carried around a star wheel, which is firmly fixed to the wheel R. A heavy weight hangs

Fig. 115.



from the other end of the chain. It is clear, that through this arrangement, with a rise or fall of the water level, both the float and the wheel R are necessarily turned in one or other direction, consequently the apparatus acts as above described. If the circumference of the chain wheel is exactly one foot and the ratio of the number of teeth of the wheels R and r as 5 to 1, it thence follows that with the rise or fall of the float by each $\frac{1}{5}$ foot, the current generator sends into one or other conductor, two short consecutive induction currents, which cause a motion of the pointer in the forward or backward direction.

The indicating apparatus shown in Fig. 114 consists of two combined magnet pointers, which work conjointly on one axis y, but in opposite directions. Fig. 115 shows the manner of the pointer's motion. The steel axle y has a strengthening piece in its centre, which carries an arm perpendicular to it. To one end

of this arm a pin is attached, around which the toothed wheel *s* revolves. A small nut prevents the falling off of this wheel. At one end of the axle is fixed the pointer *z*.

On the axle *y* there is fixed on each side a loose tube *o*, *p*, each of which carries a rachet wheel *r* on the outer end, but on the inside a crown wheel *m n*. Both crown wheels have the same number of teeth and gear mutually in the toothed wheel *s* mentioned above, of which the number of teeth can be fixed arbitrarily. The driving wheels *r* have each 60 teeth, but are so fixed to their tubes, that the one is moved to the right by its driving spring, and the other to the left. Let it be assumed that, the left wheel *r*, therefore also *m*, stands still, but the right wheel *r* is driven in the direction of the arrow ; the consequence would be, that the wheel *s* would also be turned, and thereby the arm carrying the wheel *s* and pointer *z*, would move in the same direction as the right wheel *r*, only with half the angular velocity. Exactly the same takes place though in the opposite direction, if the right wheel is held fast, and the left turned in the direction of the arrow. From this arrangement it is clear, that with the help of the above mentioned double magnet pointer, either the one or the other driving wheel can be actuated accordingly as the inductor sends the current into the one or the other conductor.

The conductor is an ordinary double telegraph line with connection to the earth at each end, and the method of joining up is made quite clear by Fig. 114.

ON THE CONVERSION OF MECHANICAL ENERGY INTO ELECTRIC CURRENT WITHOUT THE USE OF PERMANENT MAGNETS.*

When two parallel wires which form part of the closed circuit of a galvanic battery are brought near to or removed from one

* Brought before the Royal Academy of Sciences of Berlin by Professor Magnus at the session of the 17th January, 1867.

Although already included in the first volume of this collection at p. 217, this paper is reprinted here on account of its fundamental importance, and because in what follows it will be frequently referred to.

another, an increase or diminution of the current of the battery is observed, according as the motion is in the direction of the force which the currents exert on one another, or in the opposite direction.

The same phenomenon occurs with increased intensity when the poles of two electro-magnets, the convolutions of which form part of the same closed circuit, are brought near to or removed from one another.

If the direction of the current is reversed in one wire at the moments of the closest approach and furthest removal, as is done by mechanical means with electro-dynamic rotatory apparatus and electro-magnetic machines, a continual diminution of the strength of the current occurs so soon as the apparatus is set in motion. This weakening of the battery current by means of the counter current which is generated by the motion in the direction of the moving forces, is so considerable, that it explains why electro-magnetic motors could not be driven successfully by means of galvanic batteries. If such a machine be turned in the opposite direction by means of an external force, the battery current will be increased by the induced current now flowing in the same direction.

As this increase of the current also causes an increase of the magnetism of the electro-magnet, and consequently also a strengthening of the following induced current, the current of the battery increases rapidly to such a point, that the battery itself may be disconnected without any observable diminution of the current. If the rotation is stopped, the current naturally disappears and the stationary electro-magnet loses its magnetism. But the small quantity of magnetism which always remains in the softest iron, suffices, on renewing the rotation, to generate again a progressive increase of the current in the circuit.

Thus a weak current from a battery requires only to be passed once for all through the coils of the fixed electro-magnet to render the apparatus always serviceable. The direction of the current which the apparatus produces, is dependent on the polarity of the remanent magnetism. It is altered by means of a momentary current in the opposite direction passed through the coils of the fixed magnet; this suffices to give an opposite direction also, to all the subsequent powerful currents generated by rotation.

The action described, must occur indeed with every electromagnetic machine which is based on the attraction and repulsion of electro-magnets, the coils of which are included in its own circuit, but still special considerations are required to construct such electro-dynamic machines of great power. The fixed magnet encircled by the commutated currents, must have sufficient magnetic inertia also to retain unimpaired the highest amount of magnetism induced in it during the change of current, and the opposite poles of both magnets must be so arranged, that the fixed magnet has always a closed magnetic iron circuit whilst the moving one is revolving. These conditions are best fulfilled by the form of magneto machine proposed by me a long time ago, and since much used by myself and others. The rotating magnet in this, consists of an iron cylinder revolving on its axis, provided with two slots opposite to one another and parallel to the axis, which receive the insulated coil of wire. The poles of a great number of steel magnets, or in the case in question the poles of the fixed electro-magnet, surround the periphery of this iron cylinder throughout its whole length with the least possible clearance.

With the help of a machine constructed in this way, and driven at a sufficiently high speed, when the relations of the separate portions are properly determined, and the commutator is properly adjusted, currents of such strength may be generated in closed circuits of small external resistance, that the wires surrounding the electro-magnets are heated by them in a short time to such a temperature, that the covering of the wire becomes charred. When the machine is regularly used, this risk may be avoided by the insertion of resistances, or by moderating the velocity of rotation. Whilst the output of magneto-electric machines does not increase in the same proportion as their dimensions, the converse holds good in those described. The cause of this is, that the force of the steel magnets increases in a much less ratio than the mass of the steel employed in their construction, and that the magnetic power of a large number of small steel magnets cannot be concentrated in a small polar surface without weakening the action of such magnets considerably or quite demagnetizing some of them. Magneto-machines with steel magnets are therefore not adapted for use where it is required to produce very strong continuous

currents. The construction of such powerful magneto-electric machines has indeed often been tried, and such powerful currents have been produced with them, that they gave an intense electric light, but these machines were obliged to be made of enormous dimensions and were therefore very costly, moreover the steel magnets soon lost the greatest part of their magnetism, and the machines their original force. Lately, Wilde of Birmingham has considerably increased the efficiency of magneto-electric machines by combining in one machine, two magneto-machines of my above described construction. He provides the larger of these machines with an electro-magnet in place of a steel magnet, and uses the other to produce the continuous magnetization of this electro-magnet. As the electro-magnet is stronger than the steel magnet it replaces, the current produced must be increased by this combination in at least the same proportion.

It can easily be perceived, that by means of this combination Wilde has considerably diminished the above-mentioned defects of the steel magnet machine. Setting aside the inconvenience of employing two inductors at the same time to produce one current, his apparatus is dependent on the uncertain performance of the steel magnet.

By means of the method employed, electric currents can be produced in a cheap and simple manner, wherever mechanical agency is available. This circumstance will be of considerable importance in many departments of the arts.

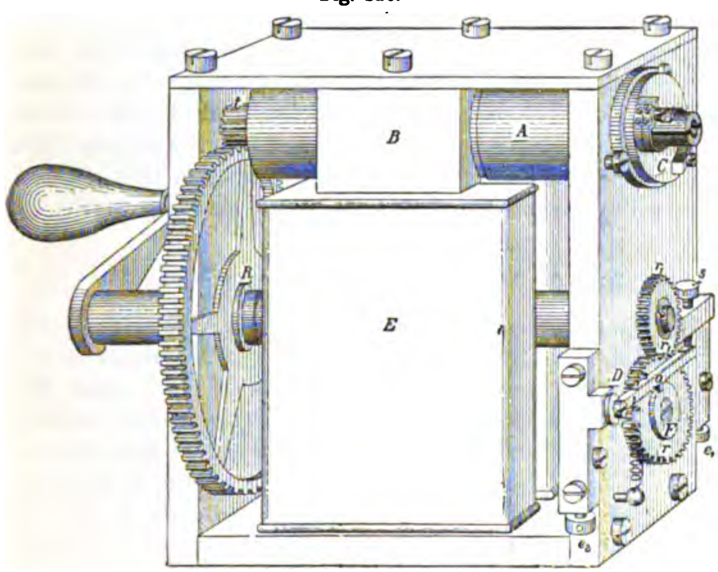
SIEMENS AND HALSKE'S DYNAMO-ELECTRIC APPARATUS FOR MINE EXPLODING AND OTHER PURPOSES IN WHICH ONLY A SHORT STRONG CURRENT IS REQUISITE.*

This apparatus differs from Siemens and Halske's old magneto-electric apparatus in that the steel magnets between the poles of

* Journal of the Deutsch-Oesterr. Telegraphen Verein, Vol. 14, p. 183. 1867.

which rotates the iron armature wound with wire in a direction parallel to its axis of rotation, are replaced by a powerful electro-magnet. The windings of this electro-magnet are traversed by the alternating currents produced in the rotating armature, after they have been rectified by means of a commutator. At the commencement of the rotation of the armature, it is only exposed to the action of the weak magnetism remaining behind in the electro-magnets; the currents produced in its windings are con-

Fig. 116.



sequently also only weak. They, however, immediately strengthen this remanent magnetism, produce thereby again stronger induced currents and so forth, until the iron of the electro-magnet has taken up the maximum magnetism of which it is capable. The current is kept short circuited by a contact spring until the handle has made two revolutions and until current and magnetism have arrived at their full development. If the short circuit is then suddenly opened, there arises in the now inserted line a short but strong current serving for the release of alarms, for firing mines, and such-like purposes.

In Fig. 116 A is the rotating armature, into the steel pinion t of which the wheel R gears. E is the electro-magnet, C the commutator. The interrupting lever D falls after two revolutions of the wheel r_1, into the notch of the disc F, fixed to the wheel r and opens the contact; after this the current passes into the line, the ends of which are fixed to the screws e_1 and e_2. The circuit of the current is shown in the diagram, Fig. 117.

The apparatus is enclosed in a wooden protecting case, which is so arranged that the apparatus when used does not require to be removed from it. The axle of the wheel R projects out of the case as a square head, to which the handle is fixed. For holding the handle a special partition is provided on the top of the case.

If the apparatus is to be used for exploding mines, fuses with conducting material or those with a conducting layer of graphite must be used. If several mines are to be simultaneously exploded, this can be done with safety if the fuses are so inserted that they are traversed by the current simultaneously and not consecutively.

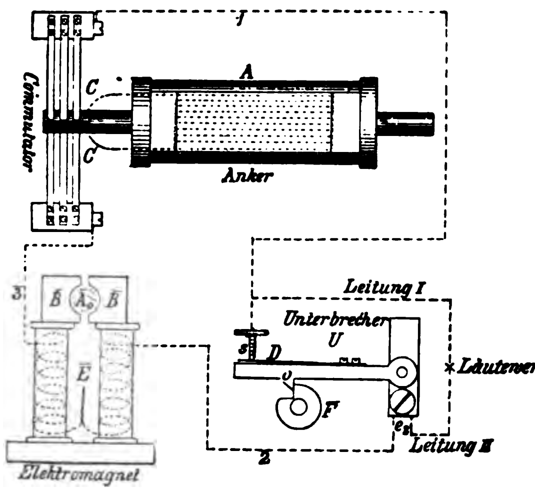
Appendix by the Editor of the Telegraph Journal.

For its better comprehension we add the following to this description, issued by the makers rather as instructions for use:—The inductor A has exactly the construction called after Mr. Siemens, who first employed it in his magneto-electric railway dial apparatus, and since in all his induction apparatus—a construction which, as already remarked, has recently been frequently adopted also by other constructors, where the production of powerful induction currents was sought.

The dotted circle A_0, in Fig. 117, indicates the actual position of the inductor between the poles BB of the electro-magnet E, but for greater clearness, and to show its connection with the commutator, it is again drawn somewhat higher in side view. The commutator C fixed to the axle of the inductor, consists of two insulated metallic semicylinders, which are continuously connected with the two ends of the wire wound on the inductor, and against which slide at two exactly opposite points two sets of springs. The number of springs in these sets only secures a greater safety in the result, in case one or other of the springs might be relaxed; in principle naturally one spring only would suffice.

One set of springs is conductively connected with the insulated metal piece e_1 (Fig. 116), bearing the contact screw *s*, the other with the beginning of the windings of the electro-magnet E, whilst the other end of the windings is in conductive connection with the metal piece e_2, bearing the contact lever D. Between the two metal contacts e_1 and e_2 the outer circuit is inserted. So long as the lever D with the nose *o* placed on its under side slides on the periphery of the disc F, and is raised thereby, a contact spring fixed on the upper side of this lever presses against the contact

Fig. 117.



screw *s*, and produces thereby a short circuit between the metal pieces e_1 and e_2; the conductor is out of circuit, and the induction currents produced only circulate through the windings of the electro-magnet E, and in the same direction owing to the commutation. But if the nose *o* of the lever pulled down by a spring falls into the notch of the disc F, the short circuit is broken and the currents now traverse the conductor until the nose *o* of the lever D is again raised. This insertion of the conductor occurs after each two revolutions of the winch handle, since the wheel *r* connected with F (Fig. 116) possesses double as many teeth as the wheel *r* keyed on the winch axle. It is evident that these relations can easily be altered as required.

As is seen, this apparatus realizes the principles explained by Dr. Siemens in the paper "On the transformation of energy into electric current without the use of permanent magnets." The reader will not fail to see that Ladd's electrodynamic machine described in the 4th and 5th parts of this journal is based on the same principles. Professor Wheatstone has explained the same idea in a paper published in the Philosophical Magazine. The priority of the invention belongs, however, decidedly to Dr. Siemens.

The first apparatus of the kind described above was manufactured in the autumn of 1866, in the works of Messrs. Siemens and Halske, and at the beginning of December of the year mentioned was shown in action to many scientific men of this country. In the first days of the year 1867 Dr. Siemens sent the above cited paper to the Academy of Sciences of this town, and it was brought forward for reading at their meeting of the 17th January. At the end of January C. William Siemens gave notice in London at the instance of his brother of a paper on the new discovery to the Royal Society of that place for the meeting of the 14th February, and somewhat later Professor Wheatstone announced a communication on the same subject for the same sitting, in which both were then delivered. Wheatstone's communication was essentially similar to Siemens'. On the 14th March Ladd came before the Royal Society with his claims, when he declared that already in 1864 he had got the idea, or that rather at that time his assistant had communicated this idea to him, but that for want of time he had not followed up the subject, until the publication of the work of Siemens and Wheatstone had again drawn his attention to it.

Ladd, on the contrary, gained an advantage as he succeeded in getting ready a large machine on this principle for the Paris Exhibition of 1867. A powerful machine prepared in Siemens' workshops, to be worked by means of a steam engine, of the wonderful performances of which for the melting of thick iron and platinum wires, producing arc lights, &c., the writer of this was often a witness, was not completed in time for the Exhibition.*

* This paper is so far to be corrected that the great machine referred to was indeed got ready for the Paris Exhibition of 1867, but as it was exhibited in the division for delicate mechanisms, in which no power transmission for working it was at disposal, it remained almost unnoticed.

SIEMENS AND HALSKE'S LARGE DYNAMO-ELECTRIC APPARATUS.*

The apparatus shown in Fig. 118, in one-eighth of its natural size has a toothed wheel R, to the axle of which a pulley S is fixed. By this pulley the machine is set in motion by means of a driving belt T. On both sides the wheel R gears into the pinions r and r' (r' is concealed in the figure) of the armatures A A′ and communicates to these a five-fold velocity. At both ends of the armatures A A′ are placed the commutators C C′ and C″ C‴, which serve to change the alternating currents of the armature into direct currents. The middle portions of the armatures A A′ lie between the poles P P′ and P″ P‴ of the bar electro-magnets E E′ and E″ E‴, the windings of which are so connected together that by the passage of the electric current, opposite magnetic poles are formed at their ends, and in such a way that for example the poles P P P and P‴ P‴ P‴ have south magnetism, and the poles P′ P′ P′ and P″ P″ P″ north magnetism. K K″ K‴ are terminals which allow of the connection of the commutators to the magnet limbs. By means of the commutator U the most varied combinations of the electro-magnets and armatures can be effected. It consists of iron cups filled with mercury, which by means of a wooden cover from which metal pins project downwards into the mercury cups, are brought into conductive connection as desired. The terminals I., II., III., IV. are the end or pole terminals of the apparatus. According to the connections of the commutator U the conducting wires are screwed in any two of these terminals. F is a strong oaken plank, to which the frame G of the apparatus is firmly screwed by means of bolts and nuts.

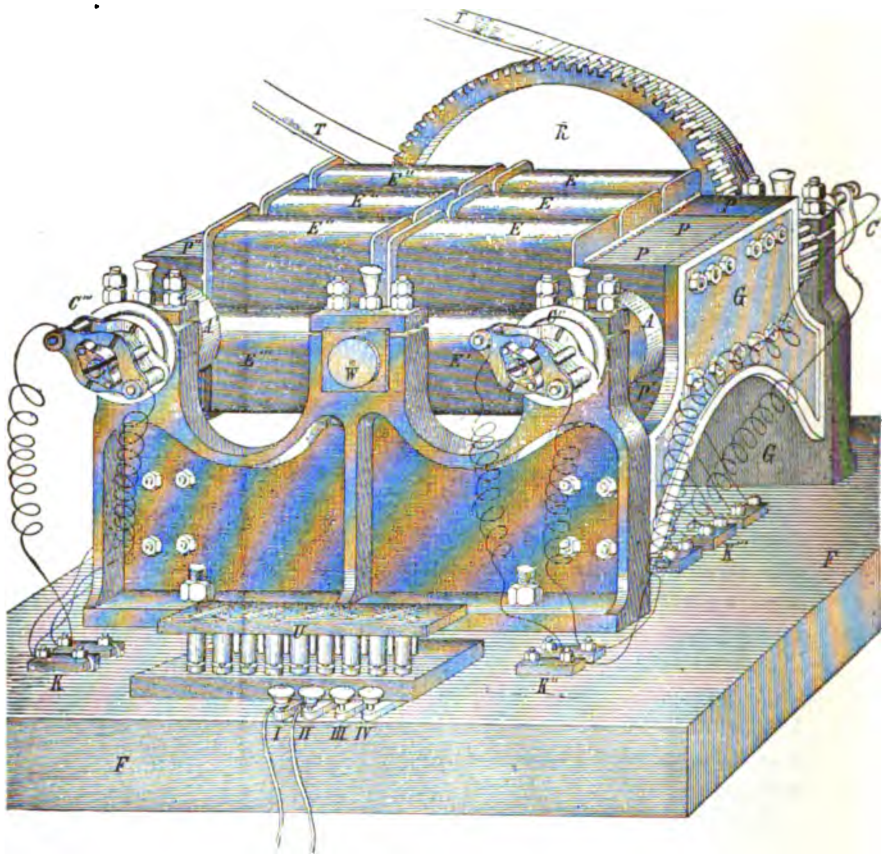
The complete apparatus weighs about 20 cwt. The total weight of the insulated copper wire on armatures and magnets is 415 lbs. An armature with wire (diameter $2\frac{1}{2}^{mm}$) weighs 60 lbs., a magnet with wire (diameter 3^{mm}) 120 lbs.; the weight of the wire alone amounts for one armature to 25 lbs., for one magnet 59 lbs. An armature has about 200 windings of 0·65 Siemens' unit resistance, a magnet about 400 windings of 0·30 Siemens'

* 1867.

unit resistance. The total resistance of the wires of the whole machine amounts to about four Siemens' units.

The usual connection of the apparatus is one in which one

Fig. 118.



armature A magnetizes the magnets, whilst the other A′ supplies the current for the line.

The dynamic as well as the light effects are quite in keeping with the size of the machine. The electrolysis of water gave 10 cubic centimetres of gas per second. The electric light was exceedingly intense, and quite blinding even by daylight.

SIEMENS AND HALSKE'S ALCOHOL METER.*

The apparatus shown in Figs. 119 and 120 is designed to show in the customary measure of the country, in the first place, how much spirit has passed through since the previous observation, and secondly, how much absolute alcohol this contained.

The apparatus has, therefore, a double object. The first, the measurement and registration of the quantity of liquid passed through is effected in the following manner :—

The spirit flows from the tube *i*, Fig. 119, into the inner cylindrical space D of a measuring drum B, having three compartments formed of tinned copper plate, which turns about its axis. The inlet tube ends in a vessel open below, surrounding the axis of the drum in a ring shape, but not touching it, which is so fixed and arranged that it does not keep the drum back by friction, and maintains the level of the liquid in the cylinder D at rest.

The three compartments I., II., III. are formed by radial partition walls, and contain each an exact quantity of liquid, for instance, four Prussian quarts. They are connected with the cylindrical space D by means of three small slits r^1, r^2, r^3, parallel to the axis. They open outwards by means of three shallow channels, which end in similar slits s^1, s^2, s^3.

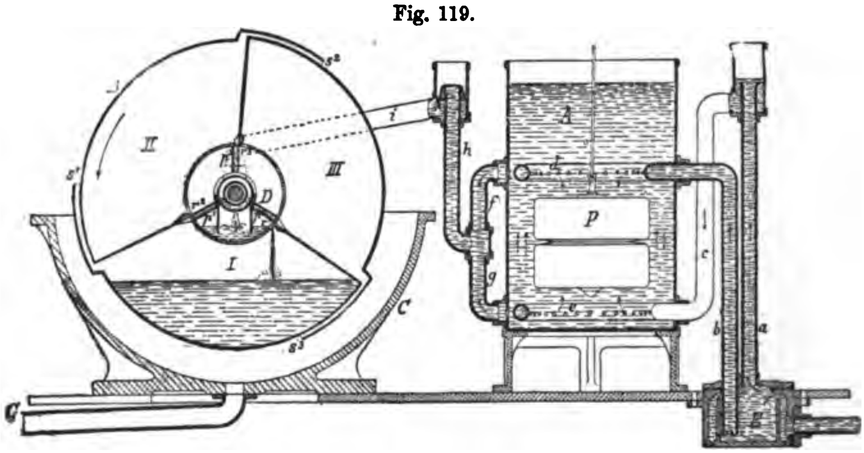
The three little tubes p^1, p^2, p^3 serve for removing the air from the compartments as they fill. As they are always above the level in D, no spirit can flow out of them.

In the position shown in the figure, spirit flows through the slit r^1 into the compartment I. As the middle of this compartment lies almost under the axis of revolution of the drum, it is scarcely rotated by the gradual filling of the compartment. Towards the end of the filling, when the slit r^1 is no longer able to carry away the spirit streaming in, the level rises in the cylinder D. Shortly after the last bubble of air disappears through the tube p^1—compartment I. is, therefore, quite full—it reaches the supply slit r^2 of the next compartment. The spirit now flows into this and so causes a lateral preponderance, by means

* Dingler's Polyt. Journal, Vol. 187, p. 295. 1867.

of which a rotation of the drum in the direction of the arrow takes place. By this rotation the slit r^2 and with it the level of the cylinder D sinks, the inflow slit r^1 of the full compartment, on the other hand, rises, and is thus raised above the level in D. When the emptying of the full compartment I. begins, through the outflow channel s^1 sinking down, only air can come in through r^1 in place of the outflowing spirit, and all the spirit entering into D during the emptying of compartment I. must flow into the next compartment II. The measurement is, therefore, quite independent

Fig. 119.



of the velocity with which the spirit runs in, as well as of the amount of friction in the axle bearings.

In consequence of the outflow through s_1 the weight on the opposite side of the drum is reduced, and the turning thereby accelerated. The emptying of the full compartment therefore takes place, when it has once begun, quickly and strongly. It brings the following compartment II. into the place of the first, and the same action begins again.

The function of the drum corresponds accordingly to a repeated separate filling and emptying of a wide measuring-flask with a narrow neck. The strong, sudden motion of the drum can be used without detriment to the exact measurement for work, such as overcoming friction and driving counters.

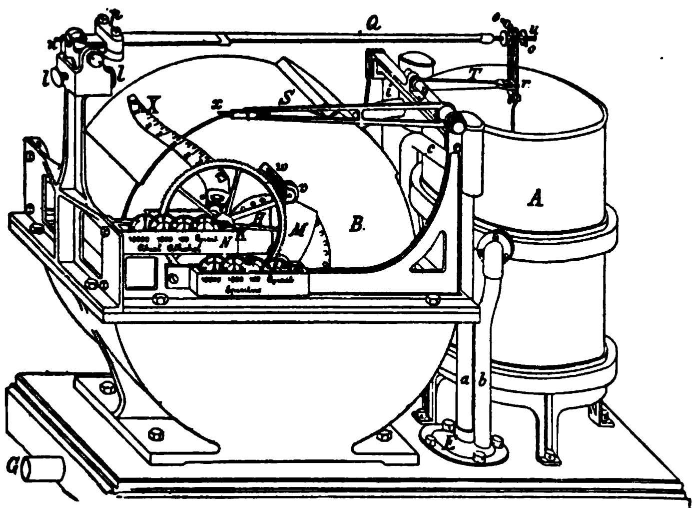
A counter on the front side of the apparatus is moved by gear

fixed to the axle of the drum, and counts directly the quantity of spirit passed through in units of the measure chosen.

The second object of the apparatus, the measurement and registration of the quantity of absolute alcohol, which is contained in the spirit passing through the apparatus, is solved, by the motion of a second counter driven by the drum, being so limited in each case by the position of a properly constructed alcohol-meter, that it gives this quantity directly.

The alcohol-meter, Fig. 120, consists of a body P, of a form

Fig. 120.



to be described later, which is suspended from a spring Q, and surrounded by the spirit passing through the apparatus.

This loses by immersion more or less weight, according as there is in the vessel A, in which it plays, spirit containing more or less alcohol, the spring Q, therefore, becomes bent to a different degree, and in consequence assumes a higher or lower position. This motion is communicated through the bar r and the lever T to the pointer S, turning around the axis y, so that the point x indicates by its higher or lower position a stronger or weaker spirit in the vessel A.

On the axis of the drum there is fixed, beside the gear which

drives the spirit-counter, the round disc M. This has three deep notches, into one of which the lever H falls, which moves around the pivot *m*, and bears on the disc by means of the roller *v*, when the drum, by emptying one compartment, turns through 120°, only, however, to be raised again at once to its original height by the next part of the disc M, which is left projecting. On this rising motion the lever takes with it the finely-toothed wheel R, by means of one of the six pawls *w*, fixed to it, which together with the gear *k* fixed to it, is pushed loose on to the axle of the lever H. This gear transfers the rotation of the wheel R in the same way to the counter M. On the lever H falling again, the wheel R is protected from back-lash by a second system of pawls, which are fixed behind the spirit-counter.

Evidently the wheel R turns the more the greater the height to which the lever H is raised, *i.e.*, the deeper it falls into the notch of the disc M. The consequence of this is that the counter N counts in the same proportion. The depth of this falling in is, however, limited each time by striking the curve X firmly connected with the lever H on the previously mentioned end *x* of the alcohol-meter's pointer.

By a suitable form for the curve X one can, therefore, impart to the alcohol-counter such a turning dependent on the position of the pointer *x*, consequently on the specific gravity of the liquid flowing through, that the readings of this counter correspond exactly with the percentage of absolute alcohol. For this purpose the curve X must be so constructed, that with a determined position of the pointer *x*, therefore, with a determined strength of the spirit flowing through, the counter N each time is pushed forward exactly as much, as there was absolute alcohol in the spirit of the compartment.

In order to obtain this it is necessary that the alcohol-meter should indicate at each instant the actual mean specific gravity of the spirit passing through. If the spirit were led through the vessel A by the help of simple in-and-out flow-tubes, it would be inevitable that with altering contents layers would be formed of different specific gravity. The float would consequently swim in spirit of a density different to that corresponding to the spirit actually flowing through the drum. To remove this source of error

the flow of the spirit must be so regulated that it mixes in a suitable way in the alcohol-meter vessel.

With this object it passes first into the lower vessel E (Fig. 119), which is connected by means of two tubes with the vessel A. The one (*b*) commences at the bottom of the little vessel E, and ends in a ring *d*, pierced with holes, placed in the upper part of the vessel A, the other (*a*, *c*) begins in the upper part of E, rises to the level of the liquid in the vessel A, and discharges in a similar way at *c* near the bottom of the vessel. Hence it follows that the poorer, and therefore heavier spirit, arriving in E, is led through the tube *b*, opening into the upper portion of the vessel A, the lighter, on the other hand, through the tube *a*, *c*, into the lower part. As in this way the heavier liquid always enters above, the lighter always below the float, a continual mixture of the newly arriving spirit with that already in the vessel takes place.

The discharge from the drum takes place through the tubes *f*, *g*, *h*, *i*, Fig. 119.

The apparatus as above described would only register the amount of alcohol correctly, if the temperature of the spirit passing through were constant, and at the usual normal temperature for alcohol measurement, viz. $12\frac{1}{2}°$ R. To make the readings correct for other and varying temperatures, a correction must be applied, making the position of the pointer *x* (Fig. 120) independent of the temperature of the spirit passing through. This is done by making the float P of thin sheet-metal, and filling it with alcohol perfectly free from air. As the float has a shape which allows the unimpeded expansion of the enclosed liquid, it undergoes in the mean the same alterations of volume as the surrounding spirit, with alterations of temperature; its position and that of the pointer *x* is, therefore, independent of its temperature. With a proper choice of the co-efficient of expansion of the filling liquid it is possible, by means of corresponding over compensation for temperature, to correct the indications of the alcohol counter, which otherwise would vary with the altered temperatures.

The apparatus thus avoids a not inconsiderable fault in alcohol determination, which has been neglected hitherto in practice. This consists in using later, for the basis of the alcohol determination, a volume which has been measured at a temperature

different from the normal, and, therefore, incorrect. The amount of this error is seen in the following example :—

Assuming, that, at a temperature of 5° C, a volume of spirit of 100 quarts is measured, this volume would increase by a rise to the normal temperature (15° ·5 C) by 0·01, therefore, to 101 quarts. Now, if after application of the correction for temperature there was found by the alcohol-meter for this observation 80 per cent. of alcohol, this corresponded to 80 quarts of alcohol according to measurements hitherto made. But there are actually contained $80/100 \times 101$, therefore 80·8 quarts, as measured at the normal temperature. The apparatus avoids this fault, as already mentioned, by an over compensation for temperature, which is to be taken into account when the reading of the same is compared with a standard.

Finally, it is to be remarked that by the play of the pointer *x*, Fig. 120, on the scale X of the curve, it can always be discovered whether the alcohol-meter is working properly. In order, nevertheless, for this purpose not to have always to fill the alcohol-meter vessel with spirit of known content and determined temperature, carefully compared weights are added to the apparatus, which correspond to the weight of the float in spirit of different strengths. These are, after removal of the body, hung instead of it to the spring at O (in pairs on both sides), and must then put the pointer *x* exactly to the corresponding mark of the scale of the curve. If differences should occur in this, these can be easily corrected by a correction of the spring by turning the screws *l* and *u*, and the agreement of the scale with the percentage content of the weights in question thereby arranged. The screws *l* correct the spring in its direction ; a turning of the nut *n*, which can take place after loosening the clamp screw *p*, alters the length of the spring. By a corresponding turning of the double nut *u*, to which the body P hangs on a knife-edge, this must nevertheless always be brought again into the original position at the lever end.

Apparatus of this kind have served for a long time past, under the control of the taxing authorities, in several countries for the continuous determination of the alcohol production of the distilleries. It has been found that the readings of the apparatus are thoroughly reliable, safer, and as exact as the closest direct determinations.

If the apparatus is to serve as the basis of the excise duty to be paid by the makers, then naturally special rules for safety must be made, which make any intentional disturbance of the apparatus impossible. If this is effected in the proper way, then a reading of the alcohol-meter at the beginning and ending of each brewing serves to show the exact amount of the object for taxation. These data are controlled by the spirit counter, which having regard to the mean strength of the spirits made, determined by frequent comparisons of the readings of the two counters, must give nearly the same amount of alcohol as the alcohol-counter.

If control is also to be kept of the time the distilling apparatus is in action during the distillation, and at what rate it has each time worked, then the control apparatus is combined with a clockwork, which makes a mark on a continuously moving paper strip at the end of each hour and another at the completion of each revolution of the drum. The clockwork must be wound up once in the course of each month.

If, on the other hand, it is considered sufficient that only the volume of the manufactured spirit should be exactly registered, and a measured proof test of each drum partition filling be retained to determine afterwards the average strength of the same, then the three-partition barrel described, with step motion, is provided with a proper proof-taking arrangement, and forms with this, leaving out the alcohol-meter and the counter for alcohol registration, an equally certain and much simpler control apparatus for the excise duty. In comparison with the above described alcohol-meter, however, it has the fault, that first the control of the reading of the apparatus is wanting, that further, the final fixing of the amount to be taxed is dependent on the official entrusted with the determination of the strength of the proof test, and that finally the determination of the alcohol itself is less exact, as the faults which are caused by varying temperatures, and by the contraction consequent upon the mixing of proof tests of different strengths, cannot be compensated. Whilst the alcohol-meter gives the alcohol passing through exact within 0·1 per cent., one must be satisfied with an exactness of ½ per cent. with the spirit-meter and taking proof tests.

The simplicity of the three division measuring-drum described,

and the great exactness with which it registers the volume of liquid passing through, has already procured its application for other technical purposes, as for instance, the measurement of the volume of vessels—such as milk-measures, beer-measures, &c., which are to be accurately gauged.

MEMOIR REGARDING THE DIRECT INDO-EUROPEAN TELEGRAPH LINE.*

1. *General View.*

One of the most important problems of the present day of the widest mercantile and political consequence is the safe and quick telegraphic connection of Europe and India. If we consider India, with its immense population and its increasing production, in itself already one of the most important trading districts of the world, at the same time as half-way house for the European intercourse with China, Japan,† Australia, and all Polynesia—an intercourse which will assume enormous dimensions—the necessity of telegraphic connection, secure in all eventualities, is self-eminent, especially since the great problem of telegraphic connection with America has been solved so brilliantly and with such extremely favourable financial results.

The trade of Europe with India, and the countries further off, is of much greater importance for Europe than that with America. This applies in a still higher degree to telegraphic intercourse. The advantage which this offers to the corresponding public, is proportional to the time which is saved by a telegraphic communication in comparison with one by letter. As now, a letter from London to America requires on the average only about eleven days, but to

* Journal of the Deutsch-Oesterr. Telegraphen Verein, Vol. 14, p. 154. 1867.

† China has about 450 million inhabitants on an area of 60,000 to 70,000 square miles; Japan, 30 to 40 millions on 7,000 square miles; British India, 136 millions on 44,000 square miles. On the other hand, the United States of America have only about 32 million inhabitants on 133,000 square miles.

Calcutta thirty days, the proportionally much greater advantage of a telegraph message to Calcutta in comparison with one to New York follows from this great saving in time. Since the telegraphic connection with America is in such good condition, that spurred on by its brilliant economical results, already competing lines are in prospect, by which the hitherto excessively high rates will probably experience a considerable reduction; since then the importance of the direct Indo-European telegraph has, moreover, considerably increased, because in future it will also accommodate the important message business of America with East Asia and Australia. If the despatch of messages is sure, quick, and not disproportionately costly, it will take possession not only of business, but also of private and political communications in a yet higher degree than is the case with other shorter, and therefore less time-saving lines. Hardly any important commercial business can be accomplished without telegraphic explanation, for the telegraphic correspondent is always some months in advance of the correspondent by letter with a simple offer and acceptance. Safe Indo-European telegraphy will, however, not only bring great advantage to already existing business, but also contribute very much to its quicker development.

2. *Insufficient service of existing lines.*

The great importance of this telegraph communication, especially for England, has naturally already occasioned many efforts to call it into existence. As the way by land through Western Asia did not appear practicable, the English Government gave a subsidy of 5 per cent. to a private company in 1856 for a cable communication to India through the Red and Indian Seas. As, however, the art of manufacturing trustworthy submarine cables at that time was only slightly developed, and the shallow and warm Red Sea, rich in coral, is highly unfavourable for laying cables well and for their maintenance, the line had already become useless before it was quite completed throughout its entire length.

The English Government, after this unfortunate costly experiment, abandoned the way by sea and sought an overland route through European Turkey and Asia Minor to the Persian Gulf and thence to India. In the year 1862 they laid, at their own cost, a

cable through the whole length of the Persian Gulf and through the Indian Ocean to Kurrachee, concluded contracts with Turkey and Persia, and supported these States in the most effective manner in the formation of land lines from the landing points of the cable to Constantinople and Teheran. In this way the English Government hoped to call into existence two competing telegraph communications between their cable and Europe: by Constantinople through southern and western Europe, and by the northern route through Russia and Prussia. These two connections have, in fact, already existed for some years, but they have not yet satisfied the existing need, and on the contrary have called forth endless complaints from the trading class, on the bad forwarding of messages. These take a long time, often weeks, on their way, and then often arrive so mutilated and falsified, that they are quite valueless to the receiver. A committee of enquiry appointed by the English Government for examining into the defective communication with India has thrown light on the causes of this unsatisfactory despatch of messages. They arise on both routes, because messages must pass repeatedly from the hands of one telegraph management into those of another, and even in the same country, frequently from one line to another. In consequence of which, the messages in their long course are frequently interrupted, and the telegraphists, who are either not at all or only partially acquainted with the English language, heap error on error by the repeated telegraphing. Add to this that by the northern route, in the Caucasus, which is traversed by the line, great climatic and physical difficulties often cause long unavoidable stoppages during the winter, and interfere with the work, and further, that the Persian line from the Russian frontier to Teheran, where the line constructed and administered by England begins, is very defectively made and worked. On the southern line, through European Turkey, Asia Minor, and Mesopotamia, there are, besides climatic and physical difficulties, considerable difficulties of a political and national character, which make regular and safe telegraphy through those parts impossible. According to the evidence of English telegraph officials well experienced in Turkish lines before the above-mentioned parliamentary committee, the oriental servants of that place fail in the trustworthiness and conscientiousness which are absolutely necessary in a telegraph servant.

Watchmen and line inspectors do not do their duty and do not quickly reinstate the lines injured by accident or intention, without first being impelled to it. All travellers in the East know the fatalist aversion of the higher and lower Orientals to hurry, and their susceptibility to "Bukshish" as well as the cuteness of Asiatic Greeks; ethical peculiarities which are directly opposed to European claims to exact performance of duty. Then the financial usages! The telegraphists do not get their salaries paid regularly, and therefore attend to the apparatus irregularly and incompletely, and are easily induced to misuse their official position. If there be added to this, the vacillating state relations of the Turkish Empire generally, and especially in the Euphrates district, which cannot be avoided, the insubordination of warlike tribes hitherto independent and unsubdued, it is clear that in England, the Government and public have come to the conclusion that a safe telegraph communication by this southern way is not to be reckoned on.

3. *European interests and concessions for the direct Indo-European Line.*

This conclusion induced the English Government again to seek a safe connection with India by the northern route, through North Germany and Russia. At its suggestion and with English cooperation, the Prussian and Russian governments have respectively bound themselves by a special treaty, to put up a direct, independent, solidly constructed line, with at least two wires between London and Teheran, which should serve exclusively for Indo-European correspondence, to avoid the Caucacus by a short submarine line, and to be throughout uniformly organized.

On the basis of this agreement, Prussia and Russia have already granted to the firms of Siemens & Halske in Berlin and St. Petersburg, and Siemens Brothers in London, a concession lasting for twenty-five years, for the erection and maintenance of a direct line between London and Teheran. A similar concession on the part of the Persian government for the tract from the Russian-Asiatic boundary to Teheran has, according to telegraphic information, just been granted. Prussia and Russia raise a moderate tax on the through messages, while, on the contrary,

Persia imposes on the undertakers only the duty to fix and maintain a special wire on the posts of the new line for its internal business. The English Government has promised the undertakers their fullest support, and has engaged with the Prussian and Russian governments to maintain the line from Teheran to India as well as the lines of telegraph in India itself, in the same degree of perfection as the new line from London to Teheran is to be kept, and to co-operate for the united organization of the technical service along the whole line from London to India.

4. *The route.*

According to the treaties with the governments named, the line is to go from London to Emden, Berlin, Warsaw, Odessa, by the Crimea, through the Black Sea to the Abasian coast, through Tiflis, Djulfa (on the Persian frontier) and Tabris to Teheran.

According to contracts with the Electric Company in London and Reuter's telegraph company, the business and interest of the undertaking on the tract from London to Emden is secured, without imposing on it the obligation of the immediate laying of a special North Sea cable. In North Germany, the Federal government is to build the lines intended for the exclusive use of the Indo-European telegraph line at its own cost, whilst the contractors have to erect the lines through Russia, Pontus, and Persia, on whom also is imposed the establishment and maintenance of the station apparatus as well as the forwarding service on the whole line from London to Teheran.

5. *Security of the line against climatic and malicious disturbances.*

Persia is to be considered as a perfectly safe land in its western portion which here comes into consideration. As stated in the above-mentioned report of the parliamentary committee, the line from Teheran to Buschir has during its many years' existence never been disturbed maliciously, and the connection between Teheran and India works regularly and to the fullest satisfaction. As little has any malicious disturbance of the line from the Russian frontier to Teheran occurred during its existence. If the

Caucasus, as proposed, is avoided by a submarine cable laid along the coast, the whole stretch from London to India along this route offers no natural or ethical hindrance which would prevent the safe service of the line. Along the whole land route, telegraph lines have already existed for years in good working order, which in Russia have been built to a great extent by Siemens & Halske, and during a period of 12 years, have been maintained by them.

The submarine cable from the Crimea to the Asiatic coast, proposed to avoid the Caucasus range of mountains, is not so long as to be able to interfere materially with the speed of signalling. As it is a coast line, and therefore can at all times be taken up and repaired, it does not materially increase the risk of the installation. If, however, it, or any piece of the land line, should become unserviceable for a time, the Russian and North German state lines are bound by agreement to help the broken section, and thus the service is secured even in such a case, which with long telegraph communications can never be quite avoided.

6. *Profits depending on increasing commercial intercourse, on international security, want of competition, and on its own performance.*

Notwithstanding the great cost of construction and maintenance in countries which have no modern means of communication, and where in part the beast of burthen still takes the place of the locomotive, the financial success of the line is to be considered as certainly secured. Already, with the present slow and insecure dispatch of messages, and the high rate of £5 1*s*. per message of 20 words, about 200 messages pass daily between England and India, a number already sufficient to make the business of the line safe. A circumstance which is absolutely proved by statistics, is that the number of messages increases with increasing rapidity, cheapness and safety of the dispatch in a quickly increasing ratio. In Prussia, for instance, the yearly increase in the number of messages amounts on an average of the last six years, to 33 per cent., and in Russia to 22 per cent. With the colossal expansion of commercial intercourse between Europe and Asia and its rapid further development, a similar increase of telegraphic intercourse is assured for a long series of years. Under these circumstances,

in calculating the profits of the undertaking, neither the number of messages handed in for dispatch on the existing incomplete lines with high tariff rates, nor the immediately existing need, can be taken as a standard, but only the capacity of the line to be erected, due account being taken of international security and the actual or prospective competition of other lines.

A comparison with the Transatlantic cable may also, perhaps, serve as a standard for this estimate.

Its takings amounted on credible authority in the first half year to about £291,000, in the following year to £430,000, the dividend to about twenty-five per cent. But the English commercial business with India, the Dutch possessions, China, Japan and Australia, considerably exceeds the total amount of the American trade.

The Exports from England to the countries mentioned above, amounted in the year 1865 to £42,897,846.

The Imports from the same to £68,117,356, without taking account of the gold trade from the Australian gold diggings.

The shipping amounted in the same year—

From England to India, to . .	1,492,102 tons
And homewards to	1,869,090 tons

This total trade of 800 million thalers, according to the communications made to the Parliamentary Committee by great mercantile firms considered as experts, is only partly telegraphic; it will be altogether so, as owing to the length of time taken in the postal service, it will be necessary for the merchant to make use of the telegraph, when this means is at the disposal of his competitors.

But the cost of establishment of a land line is very much less than that of a submarine line of less working capacity. A single core submarine line costs at least three times as much, and carries at the most only one sixth as much, as a two-wire land line.

Further, the risk connected with a deep-sea cable is much greater than with an overhead line. The injury to such a one can only be local, whilst the injury to a deep-sea cable is almost always followed by its entire uselessness and brings with it the loss of capital.

If these circumstances are taken into consideration :

1. Less cost of construction and less risk of the Indian line in comparison with the Transatlantic ;
2. Greater importance of the Indian business than of the American ;
3. Greater saving of time by the use of the telegraph and consequently greater necessity for employing it ;

then, with the known receipts of the American cable, there is no need to go into figures in calculating the profits of the undertaking.

The usefulness of the line could only be prejudiced by war. But as Persia is altogether under the influence of Russia and England, and as the peaceful desire prevails in both states to re-open the old trade route through Georgia and Persia to India,* especially as the continual political risks and internal unrest with which Turkey is visited, no longer offers sufficient security for a thoroughfare for English commerce; so only a war between England and Russia or between one of these States and Prussia, could bring about a permanent disturbance of the business of the line. The possibility of such an event cannot, of course, be denied ; yet the danger arising from this is certainly not great and the disturbance would be temporary, for the private rights to work the line would come into force again as soon as peace was re-established. It is further questionable whether a war between England and Russia would stop the service of the line for commercial messages, for its continuance is in the interest of both parties, and Prussia has besides a treaty right to demand of Russia the continuous working of the line.

The line will also be fully secured against future competition.

The alliance recently proclaimed with great noise between France, Austria, Switzerland, and Turkey, for bringing about a better transmission of messages between England and India, will not alter in the least the relations hitherto actually existing. There continues the many-handed forwarding through the French, Swiss, Austrian, and Turkish state lines with all their previous

* We mention only the steamer route on the Phasis, the great harbour buildings in Poti, the railway being built from this harbour to Tiflis, as well as the highway also in hand from Tiflis to Tabris.

inconveniences, there remains above all, Turkish conditions and Turkish population. The Berne convention would only obtain an actual advantage for the contracting states if the establishment of the direct international private line between London and Teheran *viâ* North Germany and Russia were thereby prevented. But as Russia and Prussia have given to this private line for 25 years the exclusive right to forward all messages to and from India which touch their territory, there remains, excepting the way through Asia Minor, which is known to be impracticable for a competing line, only the sea way through the Mediterranean and Red Seas, which has already once failed. The great cost and the low efficiency of long cable lines make such a connection—putting aside the risk of the capital invested in the line—impossible in case the land line in question is carried out. But even if the company which seeks to bring about a new Anglo-Indian submarine line through the Red Sea should succeed in inducing the English Government to absolutely guarantee a dividend, the competition of this line, which would not be direct but would be completed *viâ* Malta through the French and Italian state telegraph lines, would be of little weight. The English Government has meanwhile to give the perpetual subsidy for the first long-lost Red Sea line, and will now be so much the less inclined to repeat the experiment, as it would thereby compete with its own cable in the Persian Gulf.

The Indo-European line through North Germany, Russia and Persia is, according to the above, not threatened by any actual competition during its period of concession, and its profits will only depend on its efficiency.

It is the intention to construct the line with very thick iron wires, without consideration of the important increased cost, and in great part with iron posts, in order to make it as durable as possible and to increase its efficiency. With the help of the Siemens' automatic quick writer for alternating currents, in which the messages are prepared in advance either in type or in the form of a strip of paper punched with holes, and then forwarded mechanically, a single line of wire can give in an hour over a hundred simple messages of 20 words each.

The mechanical telegraphing of messages prepared in advance prevents mistakes through faulty sending or indistinct handwriting of the telegraphist.

If only mechanical signalling is carried on throughout the line, and one conductor used for telegraphing in one direction and the other in the other, the so-called translation can be applied with safety, even with alternate currents, which makes it possible to forward the messages direct from London to Teheran, *i.e.* without re-telegraphing, so that the time taken up in sending the message the whole distance is reduced to the space of about half a minute.

The efficiency of the projected double line would according to the above be equal to at least 3,000 messages daily; it would therefore, for many years to come, be able to satisfy the expected active business in messages.

For carrying out the undertaking, Messrs. Siemens & Halske in Berlin, and Messrs. Siemens Brothers in London, have in view to start an Anglo-German limited company, with a share capital of about £400,000, which will be located in London, whilst the technical administration will have its seat in Berlin. Of this capital however only 4-5ths will be subscribed, as the Russian and Prussian concessions oblige the undertakers to keep 1-5th of the capital during the whole time of the concession, in order to insure the good construction and maintenance of the line.

THE AUTOMATIC TELEGRAPH SYSTEM, INTENDED FOR THE INDO-EUROPEAN LINE.*

Already in the infancy of the electric telegraph, Professor Morse, to whom the merit of its improvement is so greatly due, recognized the great advantage which would be afforded by "automatic telegraphy," *i.e.* the forwarding of messages prepared in advance in a purely mechanical way. Vail quoted in his telegraph text-book, (Philadelphia, 1845,) two different plans of Morse for attaining this end. In both types were used, which included the dots and dashes of the Morse alphabet as short or long projections.

* Journal of the Deutsch-Oesterr. Telegraphen Verein, Vol. 14, p. 137. 1867.

These types, arranged or set beforehand as the messages, were introduced in their order into a mechanism, by means of which the long and short projections of the type produced short and long line currents necessary for the Morse writing. These plans of Morse have not had a practical result, because the telegraph-art at that time was not in a position to carry them out in a practical manner.

Bain sought in 1849 to solve the problem of automatic telegraphy in quite another way. He prepared the messages beforehand by cutting longer or shorter rectangular slits in a paper band by means of suitable stamping nippers, and these reproduced the Morse writing electro-chemically, when they were drawn under a contact spring gliding on the paper strip.

This plan also had no practical result, because the preparation of the paper band was so tedious and troublesome, and because electro-chemical telegraphs have not been proof against the charging phenomena so disturbing especially on long lines.

In 1854, I sought in company with Halske to remove the defect of Bain's automatic telegraph, by constructing a stamping arrangement with 3 keys, of which one when pressed down formed a single hole, the second a double hole in the paper strip, whilst each key on its backward stroke carried forward the paper strip by the necessary length. The third key worked no stamp but served to bring about the necessary intervals between letters and words. Instead of an electro-chemical receiver an electro-magnetic one was used, which was made to work more quickly by constructing the electro-magnet cores of slit iron tubes, and by substituting attraction between magnet and magnet for that between magnet and armature.

This system was arranged on the telegraph line between Warsaw and Petersburg. Telegraphing was carried on very quickly and safely by its means on the line in question. However it did not continue long in practical use, as the preparation of the paper strips was always so inconvenient, because it was necessary to arrange the relay specially carefully and frequently to change its adjustment to obtain good writing. We satisfied ourselves by the unsuccessful result, that the problem was not to be solved in the only way hitherto attempted, the use of simple long and short currents, and sought therefore to obtain a better basis for an automatic telegraph by the use of alternate currents. We succeeded in this with the help of

our permanently polarized electro-magnetic system. This permitted the production of Morse writing by means of short alternate currents of equal strength and duration, and quite obviated the balance spring which is so difficult to adjust for quick writing. We first sought to apply the short alternate currents by Volta induction, which was also crowned with the best results. The Sardinia-Malta-Corfu Cable in the year 1857 was the first line equipped with apparatus of that kind. Later Varley used a similar appliance on the first Atlantic cable and in other places.

As by the use of alternate currents and permanently polarized electro-magnets, the principal difficulty was overcome, which prevented the realization of the automatic telegraph, we again attempted the solution of the problem, and this time, in the manner first proposed by Morse, with the help of set-up type. This was carried out with the best result with our magneto-electric quick type-writer. The quick writer also shown in the London Exhibition of 1862, permitted of the forwarding of messages with safety through long lines with about seven times the speed of hand sending. Important considerations however could be urged against it. In the first place the apparatus had to be unusually carefully made, if it was to act well, and then the setting up of the messages was very tedious and entailed too much extra work. The apparatus is nevertheless in regular use at the telegraph station here since the year 1862, with the present modification that battery currents are used instead of magneto-electric, and it is employed specially for telegraphing meteorological and stock exchange messages.

On the 2nd June, 1858, Charles Wheatstone took out a patent in England for an automatic telegraph. This utilized Bain's perforated paper strip, and our improvement of a three-key perforator. He modified the latter by bringing our double row of holes for the production of the dashes of the Morse alphabet, not side by side, but above and below a series of middle holes. This series of holes was produced by a special third stamp which came into action by pressing down each of the three keys. For sending the messages Wheatstone used a peculiar and very ingenious apparatus, which was set in action by a handle. This was provided with three needles lying in a vertical plane, which were kept up by light springs. By turning the handle these needles were raised and

pressed against the paper strips. The middle needle always encountered a hole, and passed through it, whilst the two side needles were kept back by the paper if a signal hole were not just exactly above them. The supports of the side needles passing through the paper strips made battery contact, whilst the middle needle was pushed forward by means of mechanism, and so pushed the paper strip forward a distance corresponding to that of the two middle holes from one another.

As Wheatstone first used direct currents, his apparatus could give no certain quick writing on long lines for the previously mentioned reasons. He has, however, recently got over this by the use of alternate currents and polarized electro-magnets introduced by me.

Wheatstone's apparatus, however, always suffers—setting aside technical faults not to be referred to—in the slowness and trouble of preparing messages by means of the three-key perforator.

I have recently sought to avoid, as far as possible, the defects yet existing in this system as shewn in the above historical recital of the development of automatic telegraphy. For this purpose I have again returned to the use of Bain's paper band, after the experiment of constructing a setting machine for the quick setting and casting of types had not had the hoped-for success. As the following description of my new automatic telegraph will show, it differs from the previous attempts essentially in the following points :

1. Paper bands are employed for the reception of the messages to be punched, which are previously provided in a mechanical manner with a regular series of guide holes.

2. The punching of the writing signs is effected either by a hand perforator by means of the motion of a hand lever to the right or left, or by a key perforator. The latter has as many keys as there are letters, numbers and punctuation signs, and the momentary touching of a key suffices to punch the corresponding signs fully, and to carry forward the paper strip exactly so far that it is in the right position for the receipt of the next sign. Experienced operators can prepare three or four letters or special signs in a second for mechanical or automatic dispatch.

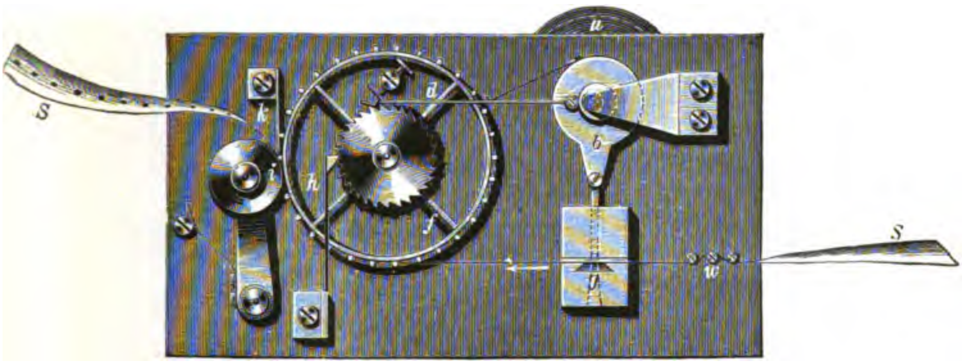
3. The automatic dispatch is effected by the help of alternating

currents, and either by means of magneto-induction or battery currents. In the latter case the dispatch is done by means of clockwork at a speed which can be regulated.

4. Good contact is assured by the use of a pencil with elastic fine wires in place of a sliding spring.

5. The receiving apparatus is an ink writer of my construction with magnet cores of thin sheet iron and a speed which can be adjusted to allow of sending as quickly as the greater or less inductive action of the line and the strength of the current allow.

Fig. 121.



This with lines of average length amounts to four or five times the speed by hand.

6. With the use of galvanic alternating currents, translation is applicable without essential reduction of speed.

Apparatus for Punching the series of Central Holes (Fig. 121).

A steel axis carries a band pulley, by which it can be quickly turned by means of a band and flywheel, and at its further end an eccentric *b*. This imparts an upward and downward movement to the small stamp, which effects the punching of the holes and a to-and-fro motion to the pawl *d*. The latter gears into a ratchet wheel with thirty teeth, which is prevented from moving backwards by the pawl *h*, and turns with this the wheel *f* fixed concentric with it, which is to move forward the paper strip S. For that

purpose it carries in the middle of the height of its cylindrical circumference a series of thirty rounded pins slightly projecting at regular distances of 6^{mm}. The paper strip is led through a narrow slit between the up and down going punch, and a correspondingly drilled small anvil *g*, and then lies on a part of the circumference of the above-named wheel. Its pins are so arranged that they fit into the series of holes, which the strip receives from the stamp. As often as a hole is finished the strip is carried forward 6^{mm}, and the place for the next hole brought under the stamp.

The correct entrance of the pins into the holes of the strip is assured by the roller *i*, which is grooved in the middle of its breadth, and presses the paper on both sides of the pin against the wheel. It can be turned back when a new strip is to be put in. The loosening of the strip from the wheel is effected by means of a thin plate *k*, which inserts itself with the front edge between the two. The three pins *w* between which the paper passes with some friction keep it stretched under the stamp.

The series of holes made by the apparatus is perfectly regular, and lies in the middle of the strip. The separate holes are $1\frac{1}{2}^{mm}$ wide and distant 6^{mm} from centre to centre.

Hand Perforator (Fig. 122).

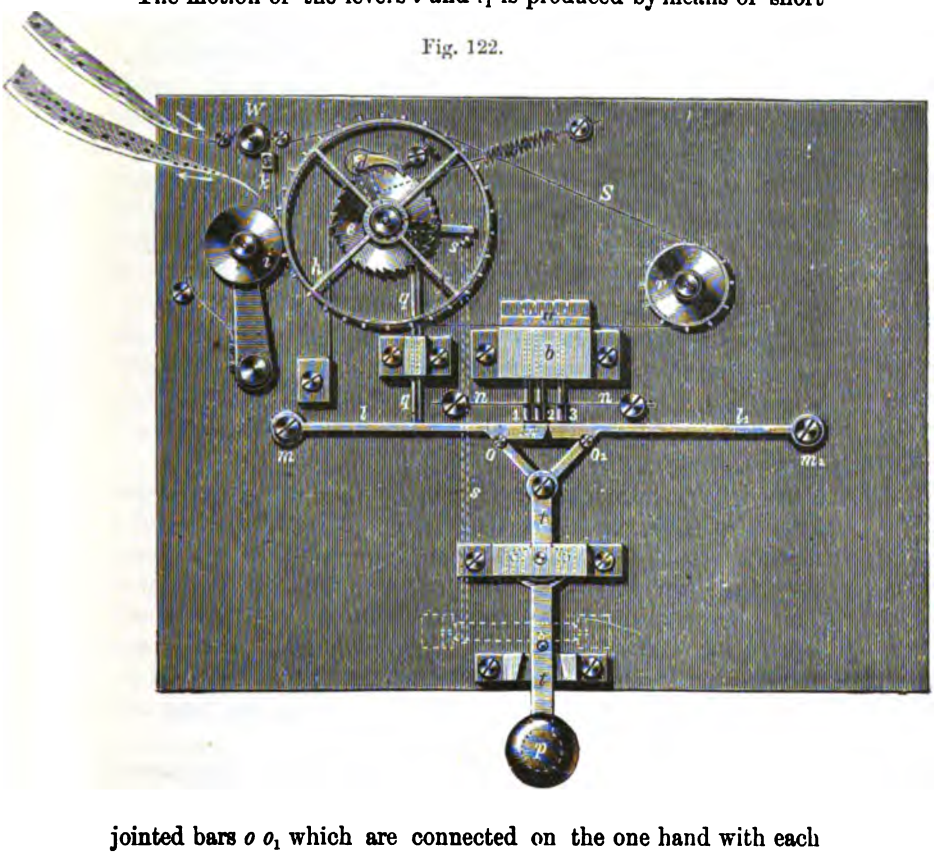
The stamp work consists of three cylindrical stamps 1, 2, 3, lying horizontally and movable in the direction of their axis, the ends of which fit tightly into the corresponding holes bored in the opposite steel plate *a* and can be pushed into them. In the small slit, which is left between this plate and the brass block *b*, which guides the stamps in their bores, the paper strip S is laid as it is supplied from the previously described machine. The stamps 1 and 2 stand 3^{mm}, the stamps 2 and 3, on the contrary, 6^{mm} apart, so that when 1 and 2 are thrust through the paper, holes are made at a distance of 3^{mm} apart, when 1 and 3 are pressed at a distance of 9^{mm}. The holes lie 3^{mm} to the side of the already existing series of holes, and as will be explained in the description of the sending instrument, produce at the desired distances dots and dashes.

The one-armed levers *l* and l_1, which turn respectively

about m and m_1 serve to press down the stamp. Their ends which gear into one another are so cut that the one (l) on being moved forward strikes the stamps 1 and 2, the other (l_1) the stamps 1 and 3. The common spring n, which is fixed at both ends and in the middle, catches into projections turned out of the stamp and draws this back when the pressure against it slackens.

The motion of the levers l and l_1 is produced by means of short

Fig. 122.



jointed bars o o_1 which are connected on the one hand with each of the levers, and on the other with the back end of the two-armed lever t, through a common pin, in such a way that a kind of double knee lever is formed. By means of it either the lever l_1 or the other l is pressed against the stamp, accordingly as the front portion of the lever t, which carries for this purpose a knob

p serving as a hand lever, is moved to the right or left. By these movements, therefore, an arbitrary row of signs representing dots and dashes can be punched, provided always that the strip is correspondingly moved past the stamps.

For this purpose the wheel *f*, with guiding pins previously described, is used, the pins entering into the series of holes previously stamped in the strip. For greater safety the strip is wound round a portion of its periphery, both before and after its passage through the punching apparatus. The loop which is thus formed is kept horizontal and stretched by means of the small roller *r* rotating with it, which also carries guiding pins on its circumference.

The motion of the levers l and l_1, of which the latter is lengthened for this purpose, is communicated to the wheel *f* by means of ratchets and pawls, and a pin *q*, so that it draws away the paper strip on the return of the lever l by one hole of the middle row, on the return of the lever l_1 by two holes.

These movements correspond, however, to the width of the signs stamped by the respective lever pins, plus the space of 3^{mm} separating them. Therefore each time the place for the next sign, which always begins near a hole of the middle row, is brought under the stamp.

Besides, the driving wheel *f* can be turned through the distance of one pin independently of the levers l l_1, by pressing the knob *p* down at its middle position, therefore when neither of the stamps is pressed. The front part of the lever *t* is fixed for this purpose at the back part to a horizontal pin, around which it can turn downwards. By means of a small bent lever and a pushing bar *s* lying under the sole plate, the motion is communicated to the pawl *d*. By means of suitably arranged springs the lever *t* is always brought back to its middle position.

In order, therefore, to represent a message with this apparatus on the strip in the form of a series of holes, the knob *p* must be pushed to the right for each dot, and to the left for each dash, besides being pressed down once for each complete letter and twice after each complete word.

With some practice the punching of the messages by the help of this apparatus can be done in almost the same time as the direct sending of them by means of the usual Morse key.

Key Perforator (Fig. 123).

The messages can be punched in the strips by means of a key perforator, in which the pressure of a key instantly furnishes a complete letter at from three to four times the speed of the hand perforator.

This is represented in Fig. 123 as seen from above. The punching apparatus contains twenty horizontal stamps *c c* lying near together, each of which is 3^{mm} distant from the next. In line with them there lie close to one another twenty striking levers $b\ b_1$, which can be moved with their front ends against the stamps by the eccentrics $u\ u^1$ placed on the common axle v, but they must be raised somewhat, when they are to strike the stamp, and thrust it through the paper.

For this purpose there lie close together immediately under the thrusting levers, and perpendicular to their direction, as many strips *a a* of sheet metal as there are signs used in telegraphy, each of which can be moved separately a little upwards by the pressure of the corresponding key.

The upper edges of these sheets, so far as they lie under the thrust levers are so filed out that each of them on rising only takes with it that lever which in their order (beginning from above) would represent, considered as holes in the paper strip, the sign in question, which is to be read on the key pressed down.

Each of the plates *a a* when it is raised turns moreover the bent lever with long axis *k*, and this at the end of its stroke sets in motion a special kind of release A, which at once couples the axle *v* with the eccentric to the axle *t* lying in its extension and kept in continuous motion by means of the band and treadle. If *v* has once turned with this, this coupling loosens again of itself, and the axle *v* stops, even when the key remains pressed down.

By this single turning of the eccentric all the pressing levers work forwards and backwards in the direction of their length, those not raised pass under the stamps, those raised strike the stamps lying in their extension through the paper and punch in it the sign of the key pressed down.

The paper strip is moved on by the pin wheel *f* and the roller *r* in the same way as with the handwriting perforator.

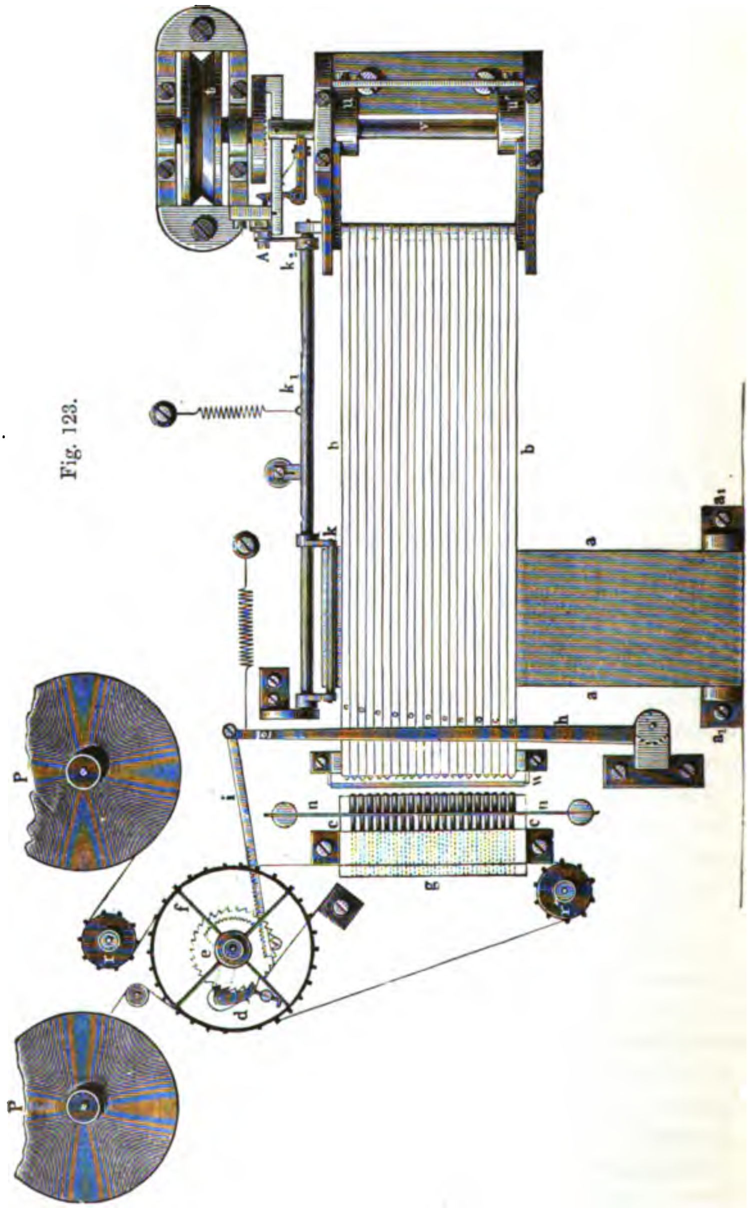


Fig. 123.

To the first there is also fixed concentrically the ratchet wheel *e*, the pawl of which can be passed over the necessary number of teeth by the tooth bar *i* gearing into a segment of a toothed wheel bearing it, which is itself fixed to the end of the lever *h*.

The lever *h*, namely, continually runs over all the thrust levers at a slight distance, and in these stick short pins standing up, which come within reach of the lever, and carry it along in their horizontal motion, as soon as they are raised, but otherwise pass under it.

As now all the pins describe an equal path, the lever *h* will be turned by so much greater an angle, the pawl of the pin wheel will catch so many more teeth the nearer the last of the raised thrust levers lies to the fulcrum of *h*.

The thrust levers are always raised in even numbers, corresponding to the nature of the perforated writing; therefore only the second of them carries a pin and the proportions are so arranged that the pin wheel catches by one more tooth, the paper strip, therefore, is drawn 6^{mm} further when a pin more is raised. Accordingly the sign to be stamped with one movement will always come out 6^{mm} wider, so that, therefore, the letters are perforated in the paper with their correct space interval.

The space between two words is produced by pressing the key without sign, the plate of which only loosens the axis *v*. The first thrust lever, opposite to which there is no stamp, and the pin of which is longer than those of the others, then presses in proper manner against the lever *h*.

Apparatus for Mechanically Telegraphing the Perforated Strips.

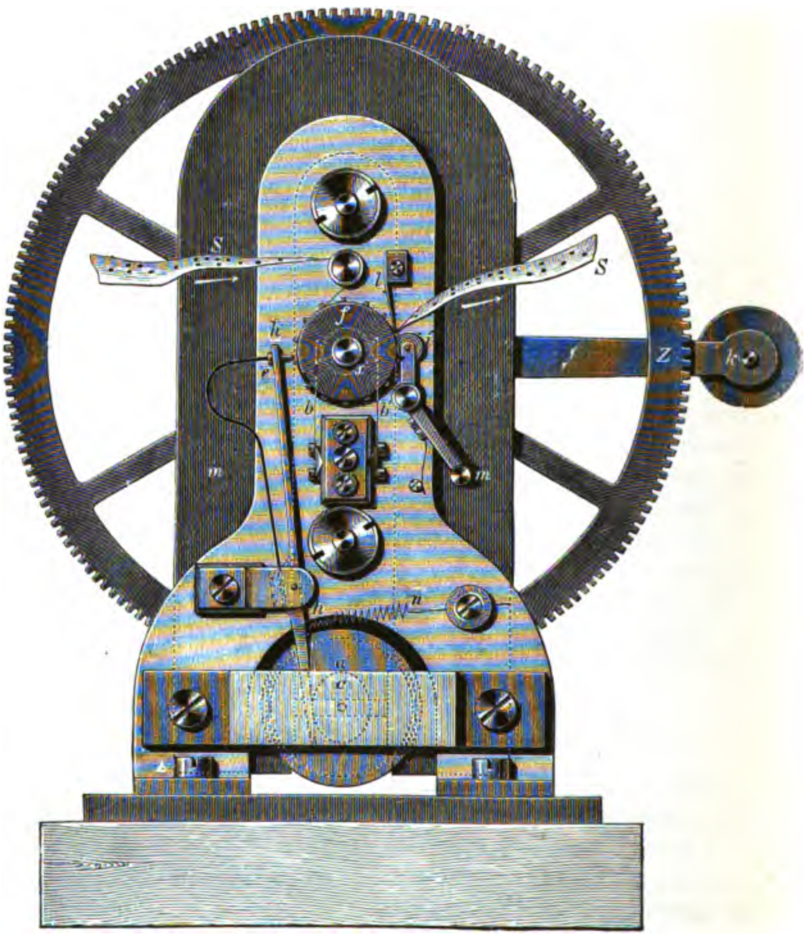
Such apparatus were arranged for use both with magneto-induction and battery currents.

A front view of an apparatus of the first kind is shown in Fig. 124. The current generator is a magneto-induction machine of our already known construction.

The cylindrical armature *a* is wound in the direction of its axis with covered copper wire and is quickly rotated between the poles of a series of horse-shoe magnets, arranged near to one another. With each revolution it gives two current impulses of opposite direction.

The axle x, which is turned by means of the arm h, carries at one end the toothed wheel z gearing into the inductor pinion, at

Fig. 124.



the other the insulated projecting pin wheel f, which provides for the forward motion of the perforated strip, because, as in the previously described apparatus, its pins enter the holes of the middle row.

The toothed wheel transmission is so arranged that as often as the wheel *f* moves forward by one pin on its circumference, therefore by 6^{mm}, the armature of the inductor turns once.

The wheel is touched by the metallic pin *e* at every 3^{mm} by the side of the guiding pins in the same plane, around which lies the row of punched holes of the strip, and just at the moment when the current passing simultaneously from the inductor reaches its maximum.

The pin *e* forms the end of a spring fixed to the end of the two-armed lever *h*, on the other end of which acts the cam *c* fixed to the axle of the armature, but insulated from it, and imparts to this, and with it to the pin *e*, forward and backward motion.

One end of the induction wire is in metallic connection with the earth through the body of the apparatus, the other with the cam, and through this with the insulated lever *h*. The telegraph line is connected to the pin wheel *f*, by means of the sliding springs *b b′*.

As often as the pin *e* touches the metal of the wheel *f* a current is sent from the inductor into the line. If, however, a strip is put in, the current can only pass when the pin *e* falls into a hole in the sign series. Otherwise the latter lies on the paper and the circuit remains disconnected through it.

The wheel *f* is so fixed to the axle that the pin *e* always touches it, the second time near a guiding pin, and the connection is so made that the current permitted thereby effects the impression of the ink roller on the paper strip in the polarized ink writer of the distant station. The direction of the current is represented by (+).

As often as a hole of the message set lying near to a guiding hole passes under the pin *e*, the latter by falling into it allows of the beginning of a sign. If now a second hole follows after 3^{mm} the (—) current caused thereby will immediately draw away again the lever of the ink roller when the inductor is rotated rapidly and a point is the result.

If, however, the next hole follows only after 9^{mm}, the (–) current can only pass on the next following revolution of the armature *a*. The ink roller, therefore, continues to lie longer on the strip and leaves a dash.

Hence, therefore, two consecutive holes of the sending strip bring about a sign, when the first of them lies near a hole of the middle row, and a space, when it lies at the side, between two middle holes. The distance of the writing holes must always amount to an uneven multiple of 3^{mm}. With uniform rotation the length of the signs or spaces produced is proportional to the distance of the corresponding holes.

Instead of the oscillating pin *e* a spring at rest can effect the closing of the circuit, which passes with its point over the writing row of the strip and falls into its holes. Several steel needles in a bundle are specially suitable for this, which sweep over the row of holes with their points like a brush.

Further, the apparatus can be so constructed that it is set in motion by means of a flywheel and pedal instead of by turning a handle. Instead of the toothed wheel transmission a band would then be used and the rotation of the armature would be communicated to the pin wheel by means of an endless screw.

Apparatus for Telegraphing the Perforated Strips with the use of Battery Currents.

If battery currents are to be used for telegraphing in place of magneto-induction currents a battery would be joined up in the circuit in place of an inductor. Moreover, the current passing from it must be reversed alternately by a special commutator, moved mechanically as often as the wheel carrying the perforated strip on its periphery turns through the distance of two pins.

To avoid the special commutator in the sending apparatus intended for use with battery currents, the pin wheel *f*, itself, which in outer form is just like that previously described, was constructed in two parts insulated from one another, KZ (Fig. 125). These fit into each other on the cylindrical surface of the wheel in a zig-zag shape, without touching each other, in such a way that two holes of the writing row lying close to one another always rest one on each of the parts. The above described steel pencil *p* (Fig. 126), which is insulated from the base of the apparatus and connected with the line serves to give passage to the current.

When it sweeps over a hole of the sign row lying near a guiding

pin it effects the connection of the telegraph line with the part K, when sweeping over the holes lying intermediately it connects with the second part Z of the wheel.

The first K of the two parts is in connection with the copper

Fig. 125.

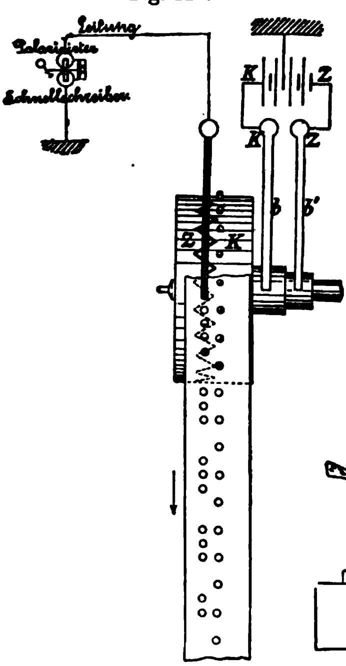
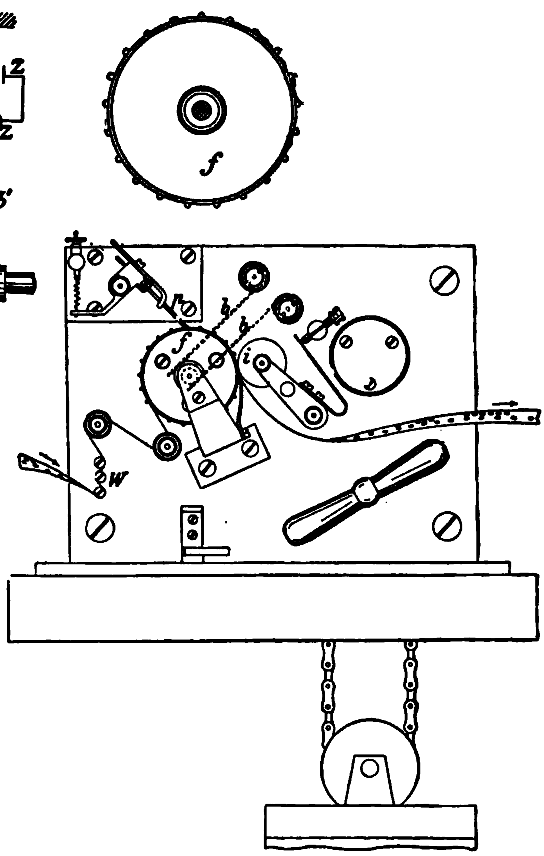


Fig. 126.



pole of a galvanic battery, the second Z with the zinc pole of a second equally powerful battery. The other poles of both batteries are connected to earth.

The working part of the apparatus is exactly the same, as that of the one previously described. As compared with this the

inductor is absent and the movement of the pin wheel only requires little power, the apparatus can instead of a handle or treadle be kept in motion by a clock-work with driving weight and fly.

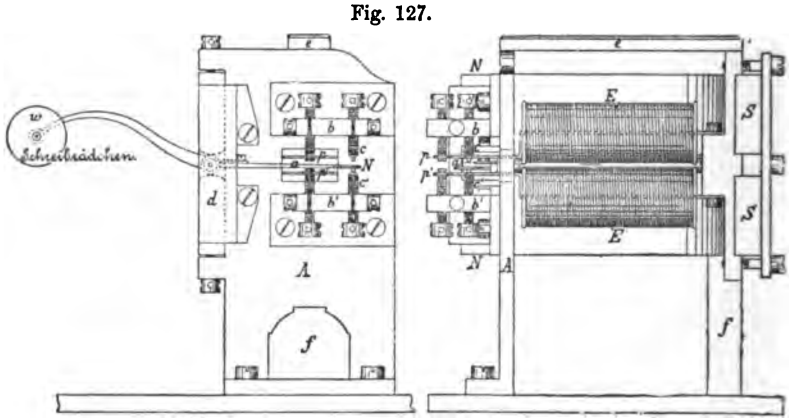
If the telegraphist has put in the message in the form of a strip containing a row of holes, and released the clock-work, the sending of the message follows without any further aid on his part.

Apparatus for receiving the message.

A. The writing apparatus.

The printing apparatus is a polarized ink writer with a new magnetic system, which enables it to work quite safely and at

Fig. 127.



unlimited speed. In place of the round hollow iron core these are here made of iron plates. The laminated cores retain very little remanent magnetism and change their polarity much more quickly than those of greater mass. The poles p p' of the electro-magnet are adjustable by means of two screws, whilst the screws c c' limit the motion of the armature a. The armature which carries at its left end the writing wheel w is made extremely light, the wheel w is formed of aluminium. As with this arrangement the weight of the mass is very small, a very quick motion of the pieces can follow. In other parts the apparatus resembles the polarized ink writer of our construction.

B. The relay.

The relay is a double polarized one also with the core and armature of the electro-magnet formed of plates. Fig. 128 is a ground plan, Fig. 129, a diagram of the apparatus. As may be seen from the latter, the two arms *e f*, lengthened towards the back form a current reverser with the stop screws. Arriving

Fig. 128.

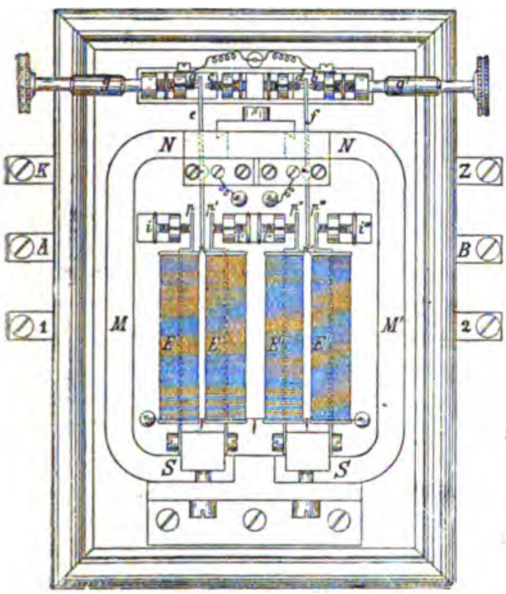
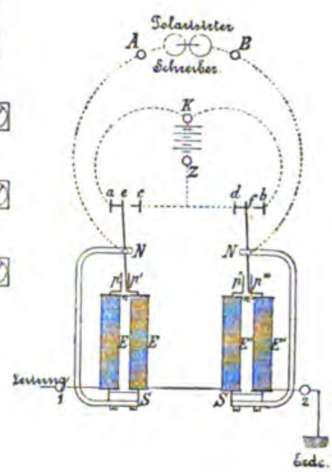


Fig. 129.



alternating currents consequently give an alternating motion to the armature, by which again a reversal of current is brought about in the line L, 1, 2, E. In Fig. 128, the permanent magnets M, M′ have north magnetism at N, and south at S, therefore the armature tongues *n n″* are also north magnetic. As alternating currents of the line L E produce alternately N and S magnetism in the poles *p p′ p″ p‴* the N tongues *n n″* are always moved towards the, at that time, south poles of the electro-magnets. Therefore the arms *e* and *f* lie respectively on the contact screws *a* and *d* or *c* and *b*. The screws *a b* are in connection with the copper pole, the screws

c d with the zinc pole of the battery. If the armatures *n n″* lie on *a* and *d*, the current of the battery passes from the copper to the left through the apparatus A, whilst it passes through the apparatus to the right when *n n″* lie on the screws *c b*. By means of the screws *g g′* the armatures *n n″* can be placed exactly in the middle of their poles *p p′* and *p″ p‴*, whilst the set screws *i i′ i″ i‴* serve to bring the poles closer or remove them from one another.

THE UNIVERSAL GALVANOMETER.*

Measurements of the galvanic factors, the strength of current, resistance and electro-motive force of batteries are tasks which now are no longer imposed exclusively on the physicist, but also and indeed more frequently must be performed by the telegraph engineer. If these tasks already require great care and precaution, the number of apparatus and instruments, which have hitherto had to be applied for the purpose is disturbing especially for engineers, as in general each of the operations referred to required another instrument specially constructed for it, which again has its own constants to be determined in the first place by special experiments.

It was desirable to possess a single instrument which is so arranged and furnished with the necessary resistances, that it can serve on occasion for each of the three operations considered.

From this point of view the universal galvanometer about to be described is constructed.

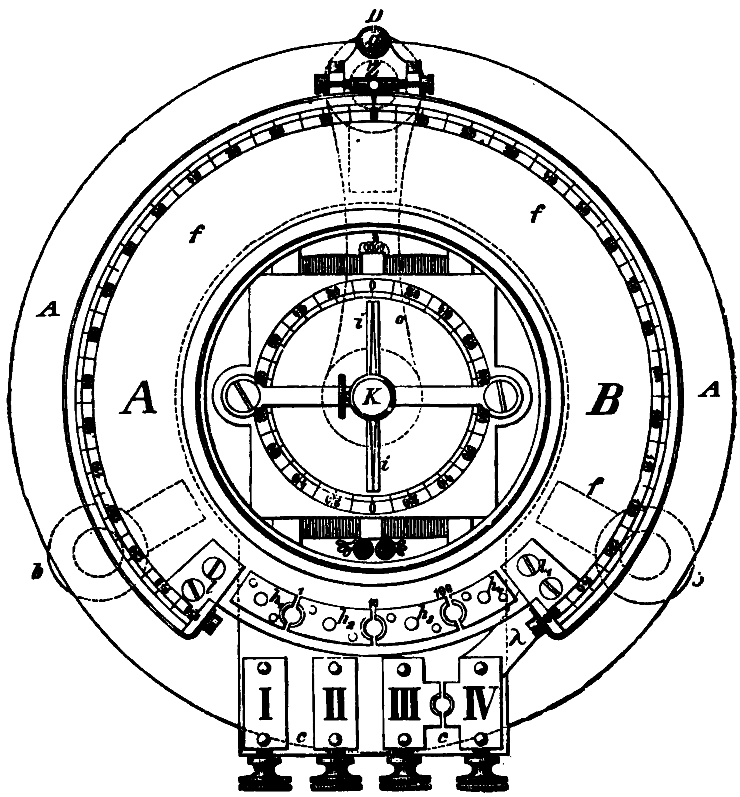
It is a sensitive galvanometer revolvable in a horizontal plane around its base, so that it can be used as a sine galvanometer combined with a Wheatstone bridge, the wire of which is however not straight, but stretched in a circle and provided with the units of measurements necessary for the measurement of resistance.

For measuring the strength of currents the instrument is simply used as a sine galvanometer.

* Journal of the Deutsch-Oesterr. Telegraphen Verein, Vol. XV., p. 1. 1868.

The measurement of E, M, F, is carried out according to Prof. E. du Bois-Reymond's modification of Poggendorff's compensation method, in which the bridge wire serves as an Agometer. For the

Fig. 130.



measurement of resistance the instrument is employed as a Wheatstone bridge.

To be able to measure great and small resistances with very great exactness three different units of measure are added of the values of 1, 10, and 100 Siemens' units, (sometimes 10, 100, 1,000 S. U.)

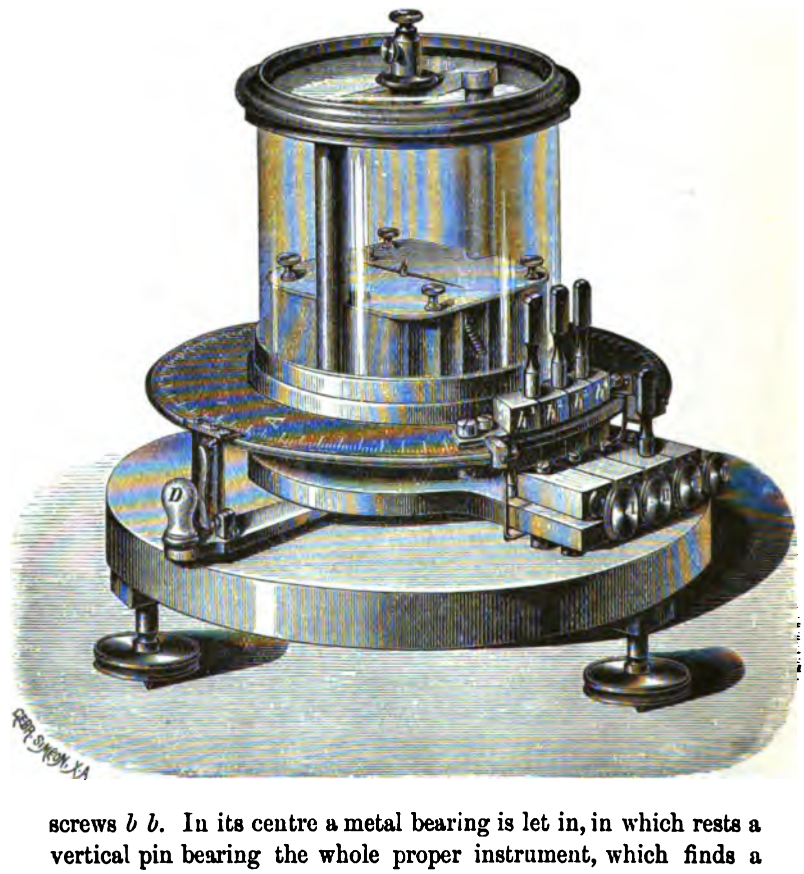
The choice of these values of the unit of measurement appears all the more justified, as in the summer of this year at the inter-

national conference held in Vienna, the Siemens' unit of resistance was officially adopted for general international business.

Fig. 130 gives the plan, Fig. 131 the side view of the instrument.

A is a circular plate of polished wood standing on three levelling

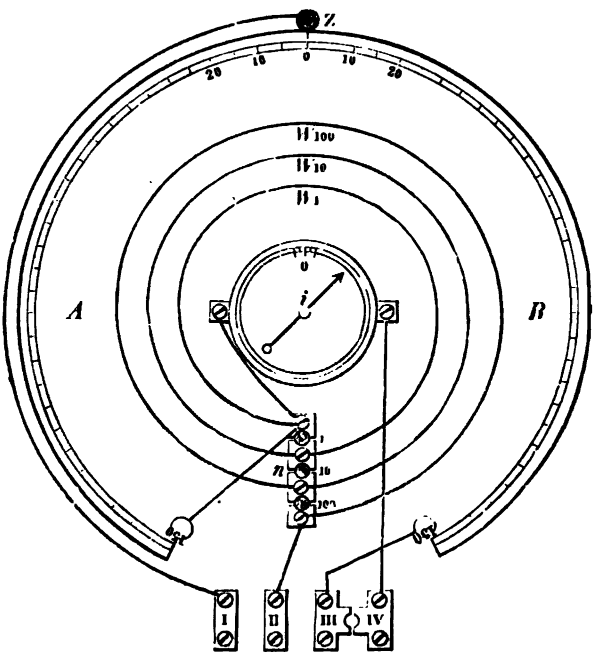
Fig. 131.



screws *b b*. In its centre a metal bearing is let in, in which rests a vertical pin bearing the whole proper instrument, which finds a very safe support in it, so that the instrument can easily turn on this pin, but without becoming loose, and without losing its horizontal position, when this has once been arranged. On this peg there next rests a circular disc of polished wood about an inch

thick furnished with the continuation *c*, in the circumference of which is turned a groove for the reception of the resistance wires. The continuation *c* carries four metal plates distinguished by I, II, III and IV and provided with terminal screws as shewn in Fig. 130. The plates III and IV can be connected together by means of a plug. Above the last mentioned disc of wood is

Fig. 132.



a disc of slate somewhat larger and turned exactly circular but somewhat cut out over the continuation *c*, and this carries the galvanometer in the centre and in front of it along the segment, four insulated metal blocks, h_1 h_2 h_3 h_4 which can be connected together with plugs, and to which the ends of the resistance wires are connected as shewn in Fig. 132.

The galvanometer has nothing unusual in its arrangement; it has an astatic needle system hung by a cocoon fibre and a flat multiplier frame with fine wires; in the example with which we

are for the moment occupied, it contains 482 windings of a resistance of 10 S. U. The needle *i* swings over a circular scale printed on cardboard and divided into degrees ; but in using the instrument, the deflection of the needle is never read, but the needle is always brought back to zero, ivory pegs are placed on both sides of this point somewhere near the division 20. The knob K to which the cocoon fibre is attached, carries also a small revolvable correcting magnet. One side of the windings as is seen in Fig. 132, is connected to the first of the blocks h_1 fixed on the slate plate, the other end to the block IV.

In the somewhat rounded periphery of the slate plate a fine groove is turned in which the tightly stretched bridge wire of platinum or German silver wiré so lies, that its outer circumference projects somewhat beyond the slate. Its ends are soldered to two brass plates l and l_1, fixed to the slate plate, exactly at the sides of the gap in it. One of these plates l is connected with the block h_1, but the other with the block III by means of thick copper wires or strips of plate. Slate was chosen for the disc *f*, because this material is from experience the least sensitive to alteration of temperature and conditions of weather. On the upper side of the slate plate its circumference is provided with a division from segment to segment, and the arc between the two segments is divided into 300 equal divisions. The zero point lies exactly in the middle, opposite the middle of the wire, and from here the graduation runs from 10 to 10 on both sides, so that the number 150 is found at both ends of the wire at l and l_1.

The movable contact point along the bridge wire is formed by the small revolvable platinum roller *e*, which is carried by an arm D, (Fig. 130 and 131,) movable below the turnable wooden disc about the pivot of the instrument and capable of easy and safe rotation around this. To this arm there is fixed, somewhat behind the handle *g*, a piece of brass in the vertical position which can be rotated somewhat between screw points, which carries the platinum roller in a slit at the upper end, and carries the bearing for its vertical axle ; a spring presses this piece of brass against the slate disc, and secures the contact of the platinum roller *e* with the bridge wire. This arm D insulated from the other parts of the apparatus, and therefore also the roller *e* is in conductive connection with the block I. To the upper portion of the piece *d* is

further fixed an index Z which projects up over the upper side of the slate plate close up to its division.

The use of the apparatus scarcely needs any further explanation after what has preceded. The diagram sketches (Figs. 133—138) will suffice. We add, nevertheless, the instructions for use arranged for engineers, as well as a table for use for resistance measurements.

As regards the arrangement of the latter, yet a few words. As appears from Fig. 133, the ratio between the resistance sought x, and the unit measure n, when the reading a falls to the *left* side of the slate plate marked with A, is

$$x : n = 150 + a : 150 - a,$$

$$\text{therefore } x = \frac{150 + a}{150 - a} \cdot n.$$

On the contrary we have

$$x = \frac{150 - a}{150 + a} \cdot n,$$

when the reading a is to the right half of the slate plate denoted by B.

The values of these two fractions, given in the Table in the columns headed A and B, for values of a increasing by 0·5.

TABLE FOR THE UNIVERSAL GALVANOMETER.

Reading a.	A $\frac{150+a}{150-a}$	B $\frac{150-a}{150+a}$	Reading a.	A $\frac{150+a}{150-a}$	B $\frac{150-a}{150+a}$	Reading a.	A $\frac{150+a}{150-a}$	B $\frac{150-a}{150+a}$
145	59·00	0·017	138·5	25·09	0·040	132	15·67	0·064
144·5	53·55	0·019	138	24·00	0·042	131·5	15·22	0·066
144	49·00	0·020	137·5	23·00	0·044	131	14·79	0·068
143·5	45·15	0·022	137	22·08	0·045	130·5	14·38	0·070
143	41·86	0·024	136·5	21·22..	0·047	130	14·00	0·071
142·5	39·00	0·026	136	20·43	0·049	129·5	13·63	0·073
142	36·50	0·028	135·5	19·69	0·051	129	13·28	0·075
141·5	34·29	0·029	135	19·00	0·052	128·5	12·95	0·077
141	32·33..	0·031	134·5	18·35	0·054	128	12·64	0·079
140·5	30·58	0·033	134	17·75	0·056	127·5	12·33..	0·081
140	29·00	0·035	133·5	17·18	0·058	127	12·04	0·083
139·5	27·57	0·036	133	16·65	0 060	126·5	11·76	0·085
139	26·27	0·038	132·5	16·14	0·062	126	11·50	0·087

TABLE FOR THE UNIVERSAL GALVANOMETER—*continued.*

Reading a.	A. $\frac{150+a}{150-a}$	B $\frac{150-a}{150+a}$	Reading a.	A $\frac{150+a}{150-a}$	B $\frac{150-a}{150+a}$	Reading a.	A $\frac{150+a}{150-a}$	B $\frac{150-a}{150+a}$
125·5	11·24	0·089	100·5	5·06	0·198	75·5	3·03	0·330
125	11·00	0·091	100	5·00	0·200	75	3·00	0·333
124·5	10·76	0·093	99·5	4·94	0·202	74·5	2·973	0·336
124	10·54	0·095	99	4·88	0·205	74	2·947	0·339
123·5	10·32	0·097	98·5	4·82	0·207	73·5	2·921	0·342
123	10·11	0·099	98	4·77	0·209	73	2·896	0·345
122·5	9·91	0·101	97·5	4·71	0·212	72·5	2·871	0·348
122	9·72	0·103	97	4·66	0·215	72	2·846	0·351
121·5	9·53	0·105	96·5	4·61	0·217	71·5	2·822	0·354
121	9·35	0·107	96	4·55	0·220	71	2·797	0·357
120·5	9·17	0·109	95·5	4·50	0·222	70·5	2·773	0·360
120	9·00	0·111	95	4·45	0·224	70	2·750	0·364
119·5	8·84	0·113	94·5	4·40	0·227	69·5	2·726	0·367
119	8·68	0·115	94	4·36	0·230	69	2·703	0·370
118·5	8·52	0·117	93·5	4·31	0·232	68·5	2·680	0·373
118	8·37	0·119	93	4·26	0·235	68	2·658	0·376
117·5	8·23	0·121	92·5	4·22	0·237	67·5	2·636	0·379
117	8·09	0·123	92	4·17	0·240	67	2·614	0·382
116·5	7·96	0·126	91·5	4·13	0·242	66·5	2·592	0·386
116	7·82	0·128	91	4·08	0·245	66	2·571	0·389
115·5	7·69	0·130	90·5	4·04	0·247	65·5	2·550	0·392
115	7·57	0·132	90	4·00	0·250	65	2·529	0·395
114·5	7·45	0·134	89·5	3·96	0·253	64·5	2·509	0·398
114	7·33	0·136	89	3·92	0·255	64	2·488	0·402
113·5	7·22	0·139	88·5	3·88	0·258	63·5	2·468	0·405
113	7·11	0·141	88	3·84	0·260	63	2·448	0·408
112·5	7·00	0·143	87·5	3·80	0·263	62·5	2·428	0·412
112	6·89	0·145	87	3·76	0·266	62	2·409	0·415
111·5	6·79	0·147	86·5	3·72	0·269	61·5	2·389	0·418
111	6·69	0·150	86	3·69	0·271	61	2·370	0·422
110·5	6·59	0·152	85·5	3·65	0·274	60·5	2·352	0·425
110	6·50	0·154	85	3·62	0·276	60	2·333	0·429
109·5	6·41	0·156	84·5	3·58	0·279	59·5	2·315	0·432
109	6·32	0·158	84	3·54	0·282	59	2·296	0·435
108·5	6·23	0·160	83·5	3·51	0·285	58·5	2·278	0·439
108	6·14	0·163	83	3·48	0·288	58	2·261	0·442
107·5	6·06	0·165	82·5	3·44	0·290	57·5	2·243	0·446
107	5·97	0·168	82	3·41	0·293	57	2·226	0·449
106·5	5·89	0·170	81·5	3·38	0·296	56·5	2·208	0·453
106	5·82	0·172	81	3·35	0·299	56	2·191	0·456
105·5	5·74	0·174	80·5	3·31	0·302	55·5	2·174	0·460
105	5·67	0·176	80	3·28	0·304	55	2·158	0·463
104·5	5·59	0·179	79·5	3·25	0·307	54·5	2·141	0·467
104	5·52	0·181	79	3·22	0·310	54	2·125	0·471
103·5	5·45	0·183	78·6	3·19	0·313	53·5	2·109	0·474
103	5·38	0·186	78	3·17	0·316	53	2·093	0·478
102·5	5·31	0·188	77·5	3·14	0·319	52·5	2·077	0·481
102	5·25	0·190	77	3·11	0·322	52	2·061	0·485
101·5	5·18	0·193	76·5	3·08	0·325	51·5	2·045	0·489
101	5·12	0·195	76	3·05	0·327	51	2·030	0·492

TABLE FOR THE UNIVERSAL GALVANOMETER—*continued.*

Reading a.	A $\frac{150+a}{150-a}$	B $\frac{150-a}{150+a}$	Reading a.	A $\frac{150+a}{150-a}$	B $\frac{150-a}{150+a}$	Reading a.	A $\frac{150+a}{150-a}$	B $\frac{150-a}{150+a}$
50·5	2·015	0·496	33·5	1·575	0·635	16·5	1·247	0·802
50	2·000	0·500	33	1·564	0·639	16	1·238	0·807
49·5	1·985	0·504	32·5	1·553	0·644	15·5	1·230	0·813
49	1·970	0·508	32	1·542	0·648	15	1·222	0·818
48·5	1·955	0·511	31·5	1·531	0·653	14·5	1·214	0·823
48	1·941	0·515	31	1·521	0·657	14	1·206	0·829
47·5	1·926	0·519	30·5	1·510	0·662	13·5	1·198	0·835
47	1·913	0·523	30	1·500	0·667	13	1·189	0·841
46·5	1·898	0·527	29·5	1·489	0·671	12·5	1·181	0·847
46	1·884	0·531	29	1·479	0·676	12	1·173	0·852
45·5	1·870	0·535	28·5	1·469	0·681	11·5	1·166	0·858
45	1·857	0·538	28	1·459	0·685	11	1·158	0·863
44·5	1·844	0·542	27·5	1·449	0·690	10·5	1·150	0·869
44	1·830	0·546	27	1·439	0·695	10	1·143	0·875
43·5	1·816	0·550	26·5	1·429	0·700	9·5	1·135	0·881
43	1·803	0·554	26	1·419	0·705	9	1·127	0·887
42·5	1·790	0·558	25·5	1·409	0·709	8·5	1·120	0·893
42	1·777	0·562	25	1·400	0·714	8	1·112	0·899
41·5	1·765	0·567	24·5	1·390	0·719	7·5	1·105	0·905
41	1·752	0·571	24	1·380	0·724	7	1·097	0·911
40·5	1·739	0·575	23·5	1·371	0·729	6·5	1·090	0·917
40	1·727	0·579	23	1·362	0·734	6	1·083	0·923
39·5	1·714	0·583	22·5	1·352	0·739	5·5	1·076	0·929
39	1·702	0·587	22	1·343	0·744	5	1·068	0·935
38·5	1·690	0·592	21·5	1·334	0·749	4·5	1·061	0·942
38	1·679	0·596	21	1·325	0·754	4	1·054	0·948
37·5	1·667	0·600	20·5	1·316	0·760	3·5	1·047	0·954
37	1·655	0·604	20	1·307	0·765	3	1·040	0·960
36·5	1·643	0·609	19·5	1·298	0·770	2·5	1·033	0·967
36	1·631	0·613	19	1·290	0·775	2	1·027	0·974
35·5	1·620	0·617	18·5	1·281	0·780	1·5	1·020	0·980
35	1·608	0·622	18	1·272	0·786	1	1·013	0·987
34·5	1·597	0·626	17·5	1·264	0·791	0·5	1·006	0·993
34	1·586	0·630	17	1·255	0·796			

Instructions for the Universal Galvanometer.

The instrument is to be used for the following purposes :—

1. *To find an unknown resistance x* (Figs. 133 and 134).

a. The needle i is brought to the zero of the small scale by turning the galvanometer.

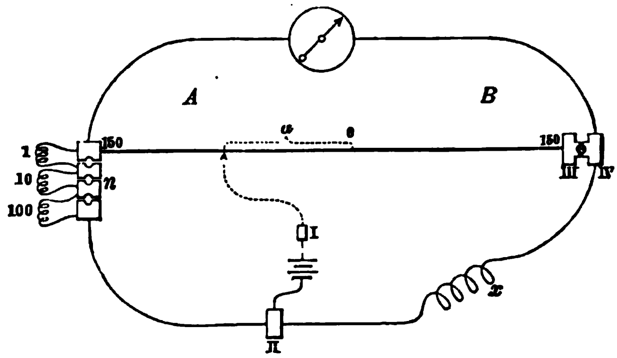
b. The pointer Z is brought by means of the handle g to the zero of the large scale.

c. The hole between III. and IV. is plugged up.

d. One of the holes, 1, 10 or 100 is opened, and always one of

the former is used when a small resistance, the hole 100 when a large resistance has to be compared.

Fig. 133.



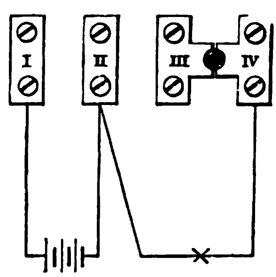
e. The two ends of the resistance to be measured are connected to the terminals II. and IV., and

f. The copper and zinc poles of a few galvanic cells to the terminals I. and II.

The needle *i*, in consequence of this connection, is, we will say, deflected to the right.

By means of the handle *g* the pointer Z is also turned to the

Fig. 134.



right to the B side of the scale. If there is then a still greater deflection of the needle to the right, the pointer Z must be moved to the left beyond the zero of its scale.

The needle thus approaches the zero of the galvanometer scale, which it reaches by further turning of the pointer Z to the left.

If the latter thereupon stops at number 50 on the A side, and if the hole 100 in n is unplugged, the following proportion results:

$$150 - 50 : 150 + 50 = n : x \text{ or } x = \frac{200 \times 100}{200} = 200 \text{ units.}$$

For the measurement of small resistances a single cell suffices. For the measurement of greater resistances and when a measurement is made with $n = 100$, about 10 cells should be used.

2. *To compare two electromotive forces E_1 and E_2* (Figs. 135 and 136).

The manipulation *a* and *b*, as in 1.

c. The hole between III. and IV. is opened.

d. The holes 1, 10, 100 are plugged up.

e. The two poles of a source of electricity of the E. M. F. E

Fig. 135.

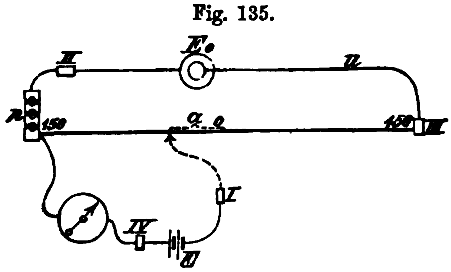
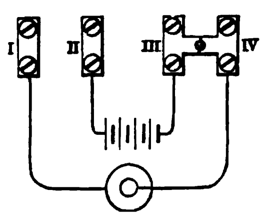


Fig. 136.



(which must be greater than E_1 and E_2) are joined up to the terminals II. and III.

f. Those of the source of electricity to be compared, for instance E are brought to the terminals I. and IV. (nevertheless so that similar poles are at I. and III., as well as II. and IV.).

The needle of the galvanometer will be deflected. By turning the pointer Z one is able at a determined position of the same to bring it back to zero. If then the pointer is, for instance, at 30 on the A side, the following equation holds

$$E_1 = E_0 \frac{150 - 30}{300 + u} \quad . \quad . \quad . \quad . \quad (1)$$

where u is the resistance of the battery E_0.

In place of the battery E_1 the battery E_2 is now inserted, the

needle becomes deflected, and can be brought back to zero by turning the pointer Z. If the pointer now stands, for instance, at 40 of the B side, the equation now holds

$$E_2 = E_0 \frac{150+40}{300+u} \quad . \quad . \quad . \quad . \quad (2)$$

From equation (1) and (2) is derived the equation quite independent of u.

$$E_1 : E_2 = (150-30) : (150+40) = 12 : 19 \quad . \quad . \quad . \quad (3)$$

Fig. 137.

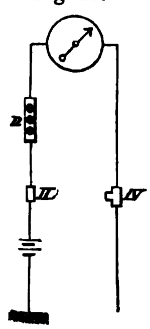
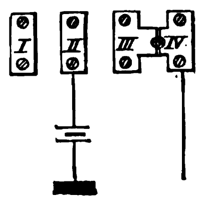


Fig. 138.



The two E. M. F. are as the two observed distances of the pointer from 150 on the A side.

3. *Use as sine galvanometer* (Figs. 137 and 138).

The manipulations *a b c d* as with 2.

e. One pole of the battery is brought to the terminal II., the other to earth, and

f. The line is connected to terminal IV.

If the needle *i* is deflected the galvanometer is turned in the direction of the deflection until it returns to zero. As by this turning the great scale turns past the pointer Z, which remains at rest, one has only to read the number at which Z stands, and to look up its sine, in order to get the number proportional to the strength of the current.

SIEMENS AND HALSKE'S HAIR-PIN GALVANOSCOPE.*

We constructed the instrument described below so as to supply the want of an instrument which should be sure to indicate weak currents of very short duration, or currents quickly alternating in direction.

It consists of a simple longish frame of wood or brass *a* (Fig. 139) which is wound with covered copper wire and inside it swings a small hair-pin shaped needle *h* of soft iron about its middle line in such a way, that its legs remain parallel with the length of the frame. For this purpose the needle is pierced at its bend and fixed on a sewing needle which has its eye removed. The point of the latter which is directed downwards between the two legs, rests in the hollow of a small stone, whilst the upper end above the bend is pivoted in a well polished hole in which it rotates easily. The oscillations of the needle are made apparent by means of a light aluminium pointer, which is fixed on the same axis and is bent down perpendicularly in front of a plate furnished with a zero line.

The needle gets its magnetism by induction from a horse shoe magnet M which is so pushed from above over the frame, that the latter is brought to lie between its legs. This magnet acts at the same time distinctly on the little needle, and by a suitable rotation of the former, the latter can be so placed that it is brought to lie with its two legs in the plane of the windings, when the aluminium pointer at the same time covers the zero line.

If a current now passes through the windings, it tends to turn the needle to one side or the other, and this very quickly follows the action of the current on account of its very slight inertia. Too great a deflection of the needle is prevented by a stop which the aluminium pointer finds on the edge of the frame opening. The strength of the directing and magnetizing force of the magnet M can be regulated by raising and lowering it.

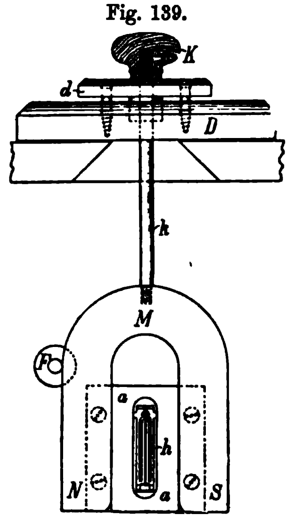
Instead of making the needle of soft iron, and magnetizing it by

* (Journal of the Deutsch-Oesterr. Telegraphen Verein, Vol. 16, p. 91.) 1868.

the action of an external horse shoe magnet, it can be made as an independent small horse shoe magnet. It is then only necessary to place above the frame a small regulating magnet *m* in Fig. 140 which gives the needle the zero position. In this form the galvanoscope is employed on the Indo-European telegraph line as a table galvanoscope, where it indicates the alternating currents used in automatic telegraphy.

We consider as new and peculiar, the use of a galvanoscope needle of hair-pin shape, which is so fixed in the opening of a

Fig. 139.



simple frame wound with covered copper wire and capable of rotation about its median line, that the legs stand parallel to the windings and which either itself consists of a small horse shoe magnet or is magnetized by induction by a steel magnet placed outside of the frame.

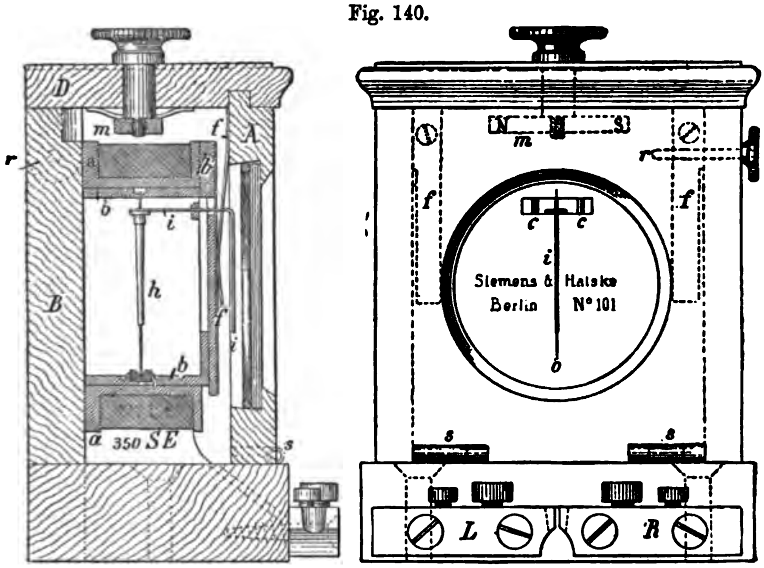
It has for the first time become possible by the use of this instrument, properly to observe and prove in a line not working itself, such occurrences as translation induction and charging phenomena. It is besides the only galvanoscope which could be used with Hughes' apparatus.

The following remarks will serve for the further explanation of Fig. 139 and 140.

Fig. 139 shows the use of the hair-pin system as a detector galvanoscope. The frame *a a* receiving the windings, is screwed to the back of the casing by means of four wood screws which are indicated by dotted lines. The frame, which contains the bearings of the needle, is fixed to the back wall of the plate provided with the zero line, before which the index plays, and together with it can be pushed in from the front into the frame and taken out.

The rod *k* on which the magnet M can be raised and lowered by

Fig. 140.



means of the knob K, for which the peg F serves as guide, goes through a stuffing box in the cover D of the casing. This consists of a thick ebonite ring pushed over the rod and lying in a cylindrical boring in the cover, a metal ring lying on this, and the cross-piece *d* also provided with a boring for the rod *k*, which is drawn together by wood screws, and thereby presses the ebonite ring fast to the rod.

Fig. 140 shews the table galvanometer of the Indo-European line, and a front view of the complete galvanoscope as well as a vertical section through the axis of the needle and the zero line.

The winding frame *a a* is here also fixed with 4 wood screws to

the back of the casing. The needle frame *b b* is pushed into it from the front and is supported in its place by two springs *f f*, fixed to the removable front of the casing *m m* is the small regulating magnet, *s s* are two hinges, about which after removal of the pin *r*, the front of the casing A and the cover firmly fixed to it can be folded up, whereby the frame *a a* and the frame *b b* are accessible. To assign narrow limits to the play of the needle, special stop pegs are placed here. The metal blocks at the foot of the instrument L and R to which the beginning and end of the windings are connected and which bear the terminals serving for inserting the instrument, approach closely to one another in the middle, and when the instrument is to be disconnected from the circuit, their end surfaces can be directly connected together placing a plug in a conical boring provided for that purpose.

ALTERNATING CURRENT-KEY WITH DISCHARGING CONTACT (SUBMARINE-KEY) FOR THE INDO-EUROPEAN TELEGRAPH LINE.*

The Key differs from the usual Morse Key in the first place in that, the movable part of it consists of two levers, 1 and 2, lying on top of one another (Fig. 141). The lower 1 is insulated from the middle piece 3 to which it is fastened by screws, and turns with this around the main axle *a* of the Key, which has its bearing in the block *b'*. The stroke of the lever 1 is as great as in the ordinary Morse Key, and is limited by means of two contacts *m* and *n* of which the first is brought into connection with the carbon pole of the positive battery, and the latter with the zinc pole of the opposite battery.

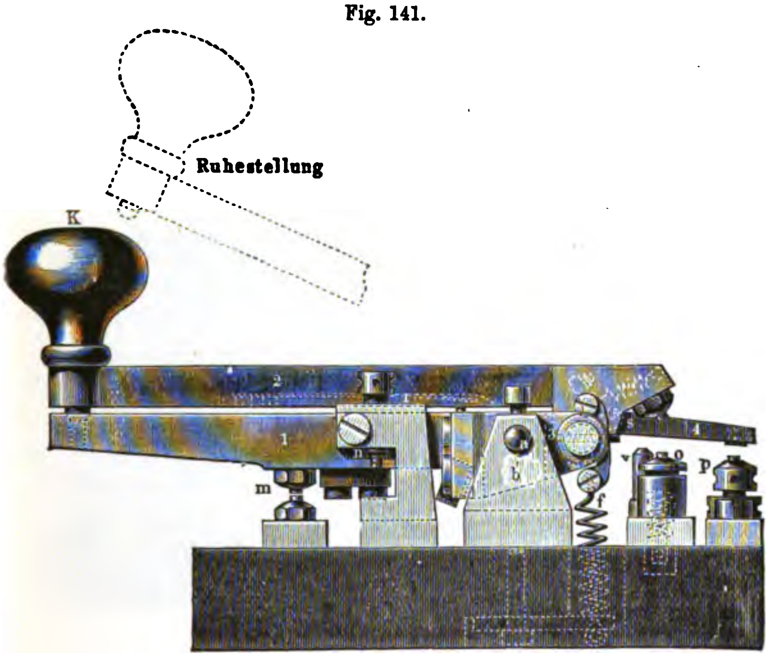
The lever 2 turns with much greater play around an axis *b* parallel to the axis *a* (Fig. 142) which is pivoted in the fork-shaped back part of the metal piece 3. On this lever 2 the spring

* (Journal of the Deutsch-Oesterr. Telegraphen Verein, Vol. 16, p. 97., 1868.

f acts so that the front end, on which the knob K rests, is drawn up, and the back end provided with a platinum contact, is pressed hard against the somewhat elastic contact *o*. This is in conductive connection with the earth through the windings of the electro-magnet of a polarized ink writer or relay S (Fig. 142).

The line is connected to the bearing block *b'* and, as the lever

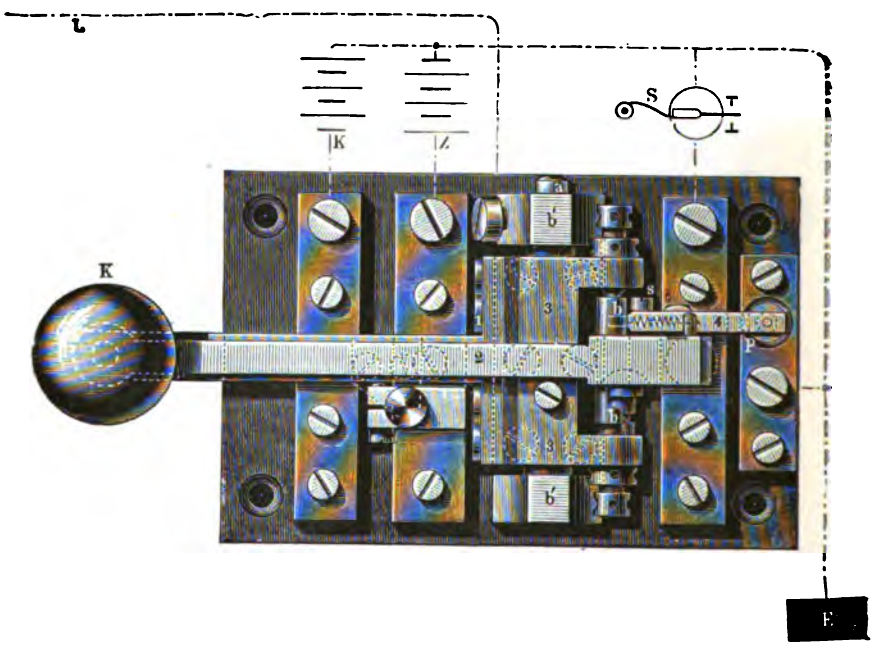
Fig. 141.



2 is in permanent metallic connection with it through the two axe and the metal piece 3 as well as through the spring *f*, the arriving current passes to the contact *o*, when the Key is in the position ot rest, and acts on the writer or relay. If a message is to be sent with the Key, the operator presses down the knob K whereby he turns the lever 2 around its axis *b*. He then first interrupts the contact *o*, and in place of it makes, towards the end of the stroke metallic connection between the two levers 1 and 2, whilst the contact spring *r* fixed to the underside of the lever 2, lies on a platinum pin fixed to the lower lever. A moment later the

front end of the lever 2 lies on the lever 1, and, from now forward both levers act as one, turning as a whole around the axle *a*, which is in connection with the line, and which is pressed strongly against the contact *n* by the spring *f* the point of application of which is considerably away from the axle *a*. The sending of the message now follows as with the usual Morse Key. A pressure brings the contact *m* to bear, through which the positive battery sends a

Fig. 142.



positive current through the line; by removing the pressure, the springs bring the lever against the contact *n* and thereby the line to the zinc pole of the opposite battery. Of course the other poles of both batteries are to earth. The correct position of the point of application of the spring *f* is of importance for satisfactory working. This indeed when the lever 2 is depressed, lies exactly perpendicularly above its axis *b*. In consequence of this, the force which seeks to separate both levers is so slight, that it is not felt by the working hand, all the less as a strong pressure is required

to press down the lever 1. By the springing back of the lever 2 nevertheless, which follows, as soon as the knob K is left quite free, the point of application of the spring *f* moves a little sideways from the axis *b* so that the pressure on the rest contact becomes powerful enough.

To prevent the charging current of the lines from passing into the relay or writer, the lever 2, before it touches with its back end the relay contact *o*, is brought temporarily into contact with the earth. The smaller lever 4 which rotates about a neck screw S, is fixed sideways from the back end of the lever 2 and reaching up over the same, and this is brought down by means of a spiral spring as far as a pin stuck in lever 2 allows. Under the projecting end of lever 4 stands the earth contact *p* but so that it does not touch this end so long as the Key works. As soon, however, as the lever 2 springs up, it sinks, and produces directly after the contact between the levers 1 and 2 is interrupted at *r*, the connection between the line and earth. As however, whilst the front end of 4 lies on the contact *p*, the fulcrum of this lever *s* with the back part of the lever 1 sinks somewhat further, the lever 4 comes soon into contact with the head of the pin *v* lying somewhat lower than the contact *p*.

This strikes the lever near to its fulcrum and on a further lowering of it, lifts it again off the earth contact, whereby finally by reaching the position of rest the connection of the line with the relay or ink writer again takes place in the contact *o*. Naturally the pin *v* does not stand in conductive connection with the earth.

The new alternate current Key does in reality the same as Siemens and Halske's already frequently described submarine Key, it avoids a special commutator the moving of which might be forgotten. The inconvenience in consequence of which the older submarine key could not obtain proper introduction, that namely the side pull which had to be continually exercised, fatigued the telegraphist, is quite got rid of with the new key in the manner described. Besides the arrangement for discharging the line is much improved.

MORSE WRITER FOR ALTERNATING CURRENTS WITH AUTOMATIC RELEASE AND TRANSLATION ARRANGEMENT FOR THE INDO-EUROPEAN TELEGRAPH LINE.*

The ink writer of the Indo-European Telegraph line, is arranged for the receipt both of hand writing and of automatic quick writing. It is essentially an ink writer of our construction with the spring drum placed outside, removable ink vessel and centrifugal regulator, which within optional limits can alter suddenly the rate of motion of the clockwork.

Fig. 143 gives a full front view, Fig. 144 a full back view of the writer.

The arrangement of the electro-magnet system is new: it consists of a cylindrical iron core which is pivoted within a bobbin C fixed between the plates of the clockwork, and wound with covered copper wire and on the ends of which projecting out of the bobbin are fixed perpendicularly the arms q and q_1 so that it forms with them a sort of horse-shoe. These arms forming the legs of the horse-shoe lie in a horizontal position, the former before the front, the other behind the back of the frame of the apparatus. Opposite to them stand the poles of a horse-shoe steel magnet M, which is pushed from above over the writer, and for regulating the apparatus is raised or lowered by turning the screw o thereby turning on a long lever arm around the axle p lying at a distance. The attraction which the magnet exerts on the limbs of the electro-magnet core, acts against the spring f† the tension of which can be regulated by the screw R. Now accordingly, as a positive or negative current passes through the convolutions of the wire, and thereby imparts to the arms of the electro-magnet the one or other polarity, the attraction of the magnet M or the pull of spring f preponderates if rightly adjusted. The electro-magnet is thereby brought into one of its positions of rest, which are given by the stops s and t

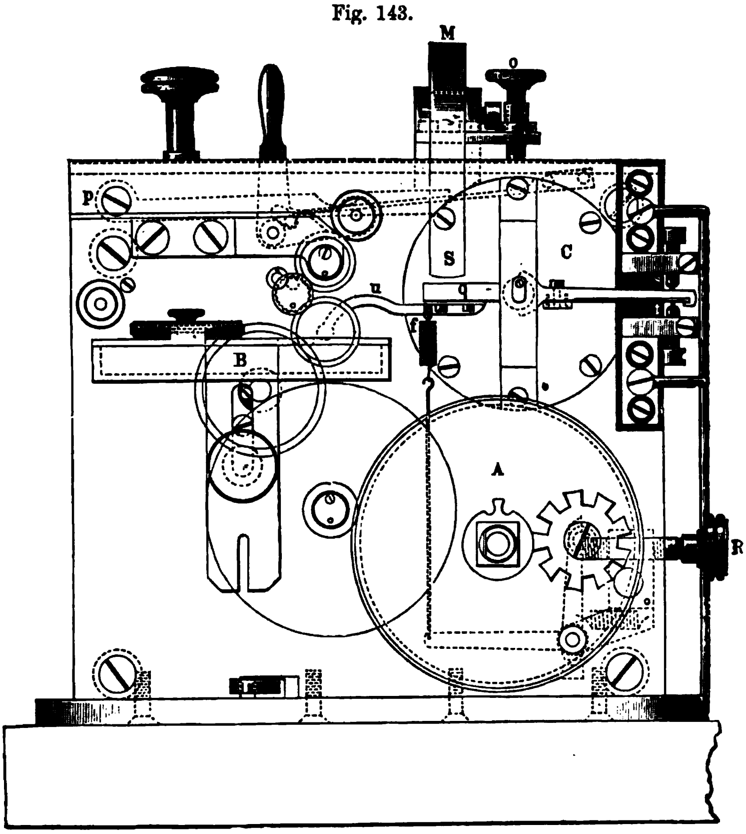
* (Journal of the Deutsch-Oesterr. Telegraphen Verein, Vol. 16, p. 99.) 1868.

† This is supported by a second spring shewn dotted in Fig. 143, which is intended to hold the bent lever, carrying the motion of the screw R to the spring f with its vertical arm always securely against the screw R.

(or translation contacts) in which it remains, even after the last current impulse has vanished.

If it is desired to work only with a direct current, the spring *f* is drawn somewhat tighter, so that it effects by itself the drawing off

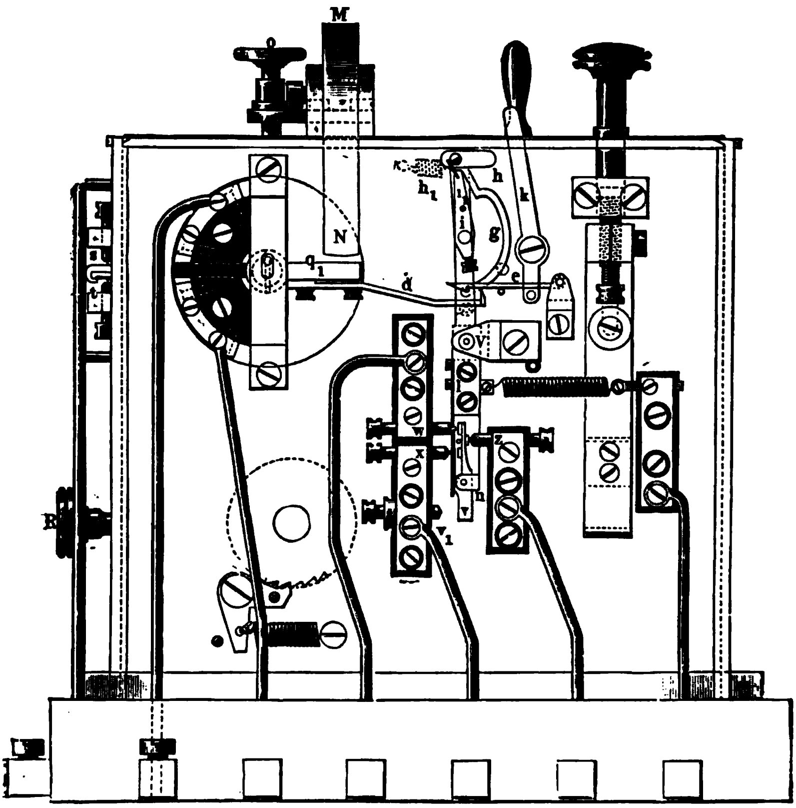
Fig. 143.



of the core, when the current in the windings ceases. To the front limb of the electro-magnet core is fixed the arm *u* in the end of which the little ink disc is pivoted; to the hind limb q^1 is fixed the German silver arm *d* (Fig. 144) which brings about the automatic release of the clockwork. The mechanism necessary for this lies on the outer portion of the back plate and works in the following way :—

When at rest, the arm *i* which is fixed to the axle of the grooved paper-carrying roller, lies with its end against the axis *h*. The latter is at the point where *i* touches it, half filed through and so turned that the point of the arm *i* lies at its periphery near to the

Fig. 144.



rim of the filed part, therefore a slight turning of the axle *h* is necessary to allow the arm to pass through the filed part, and thereby to let the works move.

In the direction of this revolution the spring h_1 acts on an arm fixed within the case perpendicular to the axis *h*, this arm can nevertheless not follow in the position of rest because the small steel hook *e* holds the curved arm *g*, which is firmly fixed

to it by a pin projecting out sideways. Directly under this hook lies the end of the German silver arm *d*, referred to. This rises at the beginning of each signal, strikes against the hook, and thereby raises this; thus the arm *g* becomes free, the axle *h* turns so far, that the point of the arm *i* can pass, and the wheel work begin to turn.

To bring about the automatic stopping of the clockwork at each pause that occurs in the sending, the pin i_1 is placed on the arm *i*. This acts in such a way on the arm *g* when *i* turns round that it pushes back the latter a little beyond its position of rest, once in every revolution just after *i* has passed under the half axle *h*, and so gives the hook *e* the opportunity to catch it again; this can however only occur permanently, when the electro-magnet and with it the German silver arm *d* are in the position of rest. In this case, a little after the hook has seized the arm *g*, the point of the arm *i* strikes against the rim of that half of the axle *h* which is not cut out, and arrests the clockwork after the last sign has just appeared on the paper strip behind the roller.

In order that the wheel work may not be damaged at the moment of the stoppage by the momentum existing in the ball regulator the pinion of the axle of the paper roller is not rigidly connected with this but fixed to it only with slight friction, as it is pressed by a spiral spring against a projection of the axis. The regulator is, therefore, not compelled to stop suddenly with the stoppage of the paper roller.

The necessary insertion and withdrawal of the second writer or opposite battery for translating by means of the alternating current, as well as the discharge of the line to earth before the insertion of the writer, is effected by the automatic release in the following way.

The axle *h* is not firmly pivoted at that end against which the arm *i* strikes, but in one end of the double armed lever *l*. This can turn through a small angle around the axis V, by which it leads the filed part of the pin *h* in a circular arc, which is a tangent to the circle described by the point of the arm *i*. Naturally both pivot holes of the axle *h*, of which one lies in the front plate, are bored so wide, that they admit the oblique position of the axle. The piece *u* is screwed on to the lower end of the lever *l*, but insulated from it, and in this a small lever *v* turns, which has

three contact pieces tipped with platinum. This is pressed by a small spring with the upper end to the left, against a pin fixed to *n*. A spiral spring draws the lever *l*, and forms at the same time its conductive connection with the contact of rest *s* on the writing lever, and eventually with the line.

By the pull of this spring, as long as the clockwork is in motion, the piece *v* is pressed against the contact *z* (pole of the negative battery) and through this against the stop mentioned, so that the lever is thus held in the position shown in Fig. 144, where its upper end has its outermost bearing to the left.

Shortly before the stoppage of the clockwork, the arm *i* presses against the axis *h* and thus moves the upper end of *l* to the right, the piece *v* with the contacts to the left. Thereby the contact *z* is first interrupted, and immediately thereafter by the touching of the contact screw *w* and the lever *v* the connection of the line with the earth, and so the discharge of the former is brought about. A little later the contact lever *v* is met by the somewhat lower lying contact screw *x*, which by the further rotation of the lever *l* again removes it from the screw *w*, thus breaking the connection of the line with earth and making that with the second writer. Lastly the lever *v* lays itself with its lower end against the stop v_1 (which is equally in connection with the second inker). By this means the lever *l* has arrived at its second limiting position, where its upper end has the farthest position to the right and the clockwork stops. Fig. 144 shows the moment when, after completion of the correspondence, and shortly before stopping the work, the arm *i* has just reached the axle *h*, and now begins to push it back and so to turn the lever *l*.

If the self-starting, together with the translation arrangement connected with it, are to be put out of play, the lever *k*, which projects beyond the cover of the apparatus, is pressed to the right; a pin on its lower end then continuously raises the hook *e*, so that it lies permanently beyond reach of the pin projecting beyond the under end of the arm *g*, so that the arm *i* can always freely pass through the slit of the axle *h*. Naturally the apparatus possesses in this case a stop of the usual construction, with brake, and spring bearing against it.

All the mechanism lying at the back of the back plates are protected by means of a casing of glass against dust and injury.

The centrifugal governor has a somewhat different construction from that shown in the 13th year of this journal,* it is somewhat easier to make and has some advantages in action: instead of two balls on curved springs two pear-shaped metal bodies are used, which fixed to straight springs lie along their whole length close to the axle. The cylindrical axle has at the corresponding part a somewhat greater diameter, and is on the two opposite sides, where the springs touch, somewhat cut away in the direction of its length, so that in the position of rest the springs lie with their outer edges within the cylindrical surface of the axle. In this way it was possible to push instead of the disc formerly used, a simple cylindrical box of somewhat greater length over the axle and springs, provided with two slits for the springs. The adjustment of this box takes place by means of a single lens-shaped disc, which may be pushed in and out, whilst formerly two were used, laid in a fork-shaped stirrup. The construction is, as already said, simpler, and acts more surely, as the springs lie fast on the axle above the removable box, and cannot bend through as is the case in the old construction.

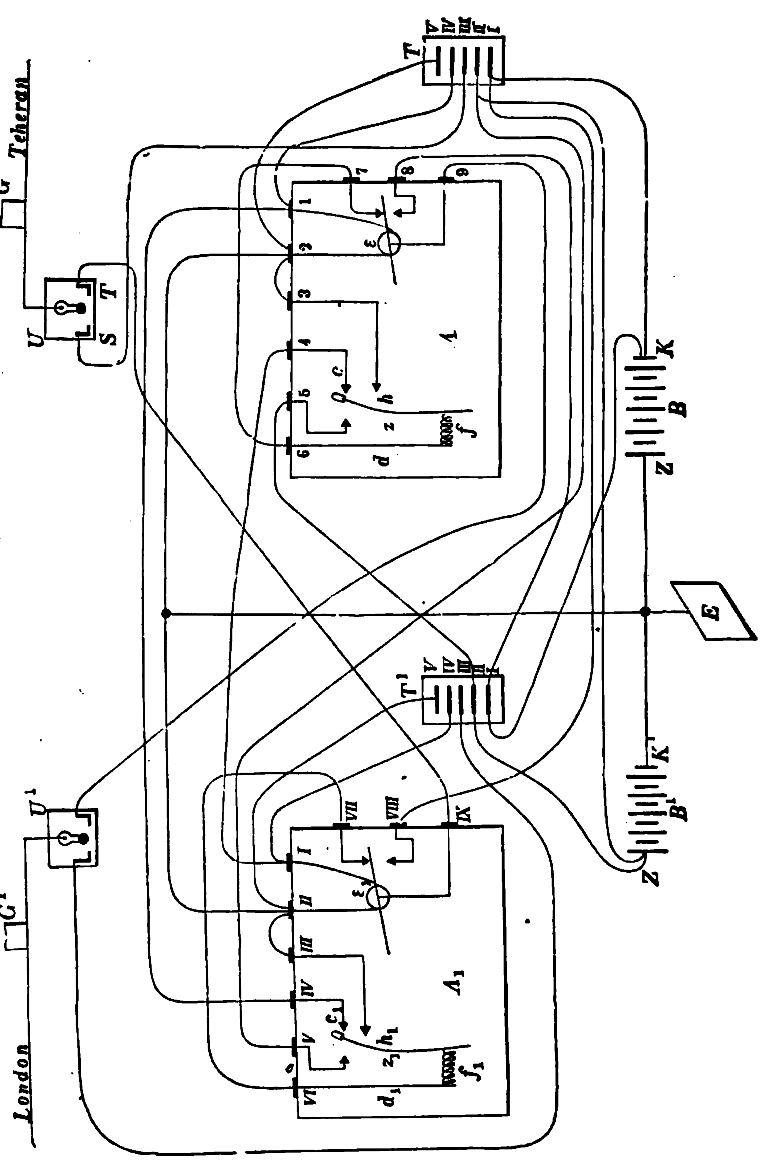
The connection of the two writing apparatus of the construction described is sketched in Fig. 145. This requires no further explanation after what has been said; the handles of the two commutators are moved to T for translation, and to S for receiving.

The above described construction of writer was prompted by the experience we gained that oscillating magnet cores which have not to magnetize armatures by induction, work far more quickly and safely than any other system. The second magnet of our induction pointer telegraph is replaced in the Indian writer by a spring, which modification is of special advantage for work with direct currents and permits of simpler regulation. With the use of alternate currents this spring naturally does not act in the sense of a pulling-off spring, on the contrary, it is then so regulated that the electro-magnet continues to lie against each of the two stops under the influence of the steel magnets, and is only made to oscillate by the impulse of current of alternate direction.

The automatic release is first of all intended to undertake the

* See pp. 233–237 of this collection.

Fig. 145.



change of connections necessary for the translation of alternate currents, *i.e.*, at each beginning of the translation to put the negative battery in place of the second writer on to the rest contact of the lever.

If the automatic release is only desired as such the whole contact arrangement is omitted and the half filed axle *h* is firmly pivoted in a small angle-piece.

SIEMENS AND HALSKE'S TELEMETER WITH INTERSECTING POINTERS AND WITH MIRROR READING.*

1. *Telemeter with Intersecting Pointers.*

The two apparatus used for measurement are set up at a known distance apart, which serves as a basis for the distance to be determined. If the latter is to be measured from one end only of the base, the apparatus are arranged according to the following diagram (Fig. 146).

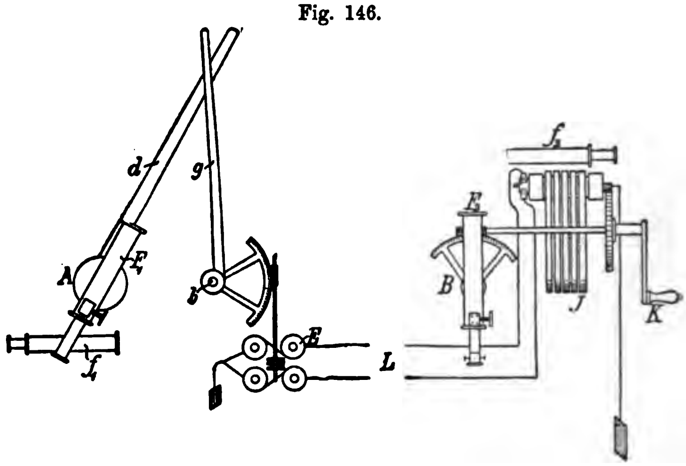
Each of the two parts carries a telescope (F_1 F_2) with cross wires which turns round the respective end point of the base, and serves for observing the distant object. The telescope of one apparatus A carries a pointer *d*, the straight edge of which passes through the axis of the telescope and is in the same direction as the line of sight. By turning the telescope it glides over a surface of wood or metal. A second pointer *g* turns around the axis *b* so that it remains at very little distance from the surface in question and slides over the pointer *d*. The distance of the two axes A and *b* is in a determined proportion to the base A B, and the apparatus is so set up that the latter passes through both axes. For this purpose the small telescope f_1, fixed to the board, serves, which is directed to a corresponding mark drawn on the other apparatus B. Before the measurement begins the telescope F_2 and the pointer *g* must be parallel. For this purpose a mark on A is sighted with the fixed telescope f_2 of apparatus B, and the pointer

* 1868.

g and telescope F_2, set to corresponding marks or stops, of which as many as desired can be arranged.

Now both observers direct their telescopes to the object whose distance from A is to be measured, the one at A by turning directly by hand, the other with the help of the handle K. By the latter an endless screw is turned which gears into a toothed sector, firmly fixed on the axis of the telescope, besides, by means of a toothed wheel and pinion the armature of a magneto in-

Fig. 146.



ductor J of our construction is set in rotation. The alternate currents thus generated pass through two conductors and earth at A to an electro-magnetic apparatus E, which again with the help of an endless screw and a toothed sector turns the pointer *g* in such a way that it always remains parallel with the telescope F_2, no matter whether the observer at B turns forwards or backwards.*

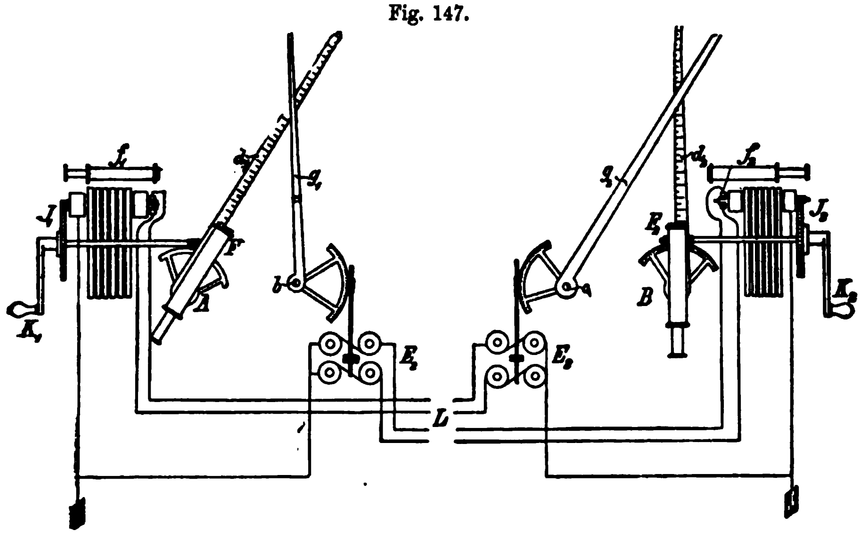
Hence the intersecting edges of the pointers *d* and *g* and the line A *b* form a triangle, which is similar to the triangle formed by the lines of sight and the base A B, as all the corresponding

* The electro-magnetic apparatus E consists similarly to that constructed to measure water levels shewn at p. 253 of this collection of two combined magnetic pointers, which work round on the same axis in opposite directions ; on this axis is the endless screw which turns the pointer *g* by means of the toothed sector.

sides have the same direction. The piece of the edge of g cut off by d is directly proportional to the distance to be measured.

This can be read at the point of intersection of both pointers if each is divided in the corresponding proportion of A b to A B. If the apparatus used for coast batteries is to show when an enemy's ship passes a mine, a plan of the mine field is placed under the pointer on which the points A and b represent the points A and B of the ground. If both observers keep the same

Fig. 147.



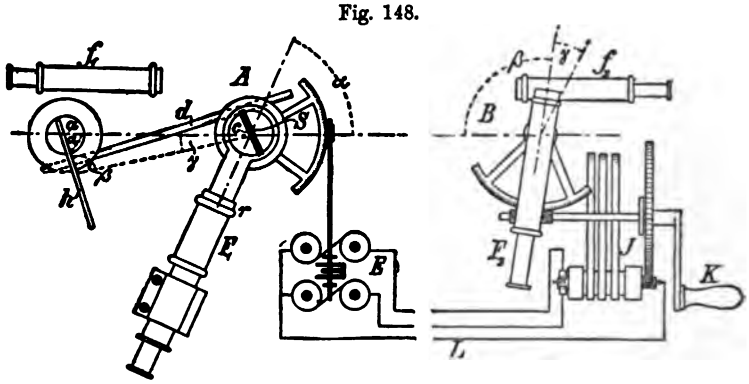
part, for instance the mainmast of the moving ship on the vertical thread of their cross wires, the moving point of intersection of both pointers represents the course of the ship on the plan.

If the respective distances of an object are to be measured from both ends of a base, each apparatus possesses a magneto inductor (J_1 and J_2, in Fig. 147), by the turning of which the observer directs his telescope with pointer (d_1 d_2) mechanically to the object; also a second pointer (g_1 g_2) which is maintained parallel to the distant telescope by the currents of the other inductor. Both apparatus are otherwise made quite symmetrical to one another.

2. *Telemeter, with Mirror Reading.*

The previously described apparatus are only available when a sufficiently long base is at disposal. In consequence of the angle at which the edges of the pointers cross, the reading is not reliable, whenever the distance to be measured exceeds three times the base. When sighting objects in motion the distance cannot be read off by the same observer who directs the telescope; besides the

Fig. 148.



apparatus are in consequence of the long, lightly constructed pointers, somewhat unwieldy and not fit for frequent transport.

These objections, which make telemeters with intersecting pointers inapplicable for use on ships or in the field are overcome in the apparatus shown in diagram in Fig. 148.

Both parts stand on tripods of simple construction, by which the alignment of the telescopes f_1 f_2 can be effected, and without interfering with this, the elevation of the telescopes F_1 F_2 to be directed to the object can be altered.

The conductors L consist of a three-cored cable, with which also the base A B is measured when used in the field.

The part to be set up at the end B of the base is the same as that used by us in the previously described apparatus with pointers. By turning the handle K one observer directs his telescope F_2 to the distant object, and at the same time quickly turns the armature of the inductor J, which sends its currents into the electro-

magnetic apparatus E at the other end. This rotates by means of an endless screw and toothed sector, instead of the long pointer the small vertically fixed mirror S around C in the same direction, and just half as quickly as the simultaneously turning telescope F_2. In this mirror the observer A sees in the lower half of his object glass the ivory scale *h*, which is made clear for him by means of a movable half lens *r*, with the upper half of the object-glass he views the distant mark above the half lens and the edge of the mirror, so that scale and object lie in the telescope.

In order to direct the telescope to the object, it is turned concentrically with the mirror S around *c*, whereby the independent turning of the mirror is not interfered with. By means of two toothed sectors, one of which is fixed to the telescope support, the other to the scale, and the toothed rod *d*, which gears with its ends in it, the scale is turned about the point *a* equally quickly in the other direction. As, moreover, the telescope axis and scale simultaneously stand perpendicularly to *a c*, the angle which the scale forms with *a c* is always equal to the angle of the line of sight at F^1, with the extension of *a c* or the base A B.

Before the measurement begins, both telescopes F_1 and F_2 are arranged parallel to one another in the usual manner. The observer at A also turns with his hand the mirror S, so that he sees the zero point *a* of the scale on the vertical thread. For this the spindle is temporally put out of gear with the sector. If now both telescopes are turned through the same angle of any size, so that they remain parallel to one another, then from what precedes since the mirror S turns with it through half the angle, the vertical threads of F_1 remain unaltered on the zero line of the scale.

If, however, both telescopes are directed to a finitely distant point the mirror *s* remains behind by half the angle of convergence of both telescopes.

The main ray passing through the cross wires after reflection falls no longer on the mirror in the direction *a c*, but forms with it the full angle.

The observer at A therefore no longer sees the zero line on the vertical thread simultaneously with the distant object, but another division of the scale distant from the first by *a b*.

As the angle γ occurs also at the point C in the large triangle A B C formed by the lines of sight, and this latter besides γ as

mentioned, has also the angle *a* common with the triangle *a b c*, these two triangles are similar to one another. Hence if D is the distance, A C to be measured, *w* the distance *a b* of the division appearing in the thread cross reckoned from the zero line of the scale.

$$D = \frac{A\,B\,.\,a\,c}{w}$$

If, for instance, the base A B measured by the cable = 100 paces, the permanent distance $a\,c = 150^{mm}$ as given by the construction of the apparatus, and the scale is also divided into millimetres, starting from *a*, then the distance to be determined is calculated

$$D = \frac{100\,.\,150}{w} \text{ paces,}$$

hence we obtain, for instance,

$w = 1^{mm}$	$D = 15000$ paces
$w = 2$ „	$D = 7500$ „
$w = 5$ „	$D = 3000$ „
$w = 10$ „	$D = 1500$ „

The scale *h* is in this case divided into tenths of a millimetre, which, magnified by the telescope can be easily read. Hence, for instance, the distance between 3000 and 1500 paces can be divided into 50 parts.

In the apparatus with pointers the latter would have to be 8^m long so as to be able to measure, in the case in question, the distance of 1500 paces.

If the above equation is solved for *w*

$$w = \frac{100 \times 150}{D}$$

then, according to this equation the scale can be directly divided according to the distances. With proper arrangement of both apparatus the observer then sees simultaneously with the object that number of the scale on the vertical thread of his telescope, which represents the distance of the object.

PROPOSAL FOR AN ELECTRIC VOTING TELEGRAPH.*

The electric voting telegraph as proposed by me already ten years ago to the then President of the House of Deputies is represented in the following plan in ⅙th of its natural size. (Fig. 149.)

It has a double object. In the first place, it has to give with certainty on three counters the total number of voters, and the number of Ayes and the number of Noes. The control of the correctness of these numbers consists in the sum of the Ayes and Noes agreeing with the total number.

Secondly, the apparatus has to mark clearly in oil colours on a paper strip, which is printed with the names of all the deputies, opposite the name of each one, who has given his vote whether he has voted Aye or No.

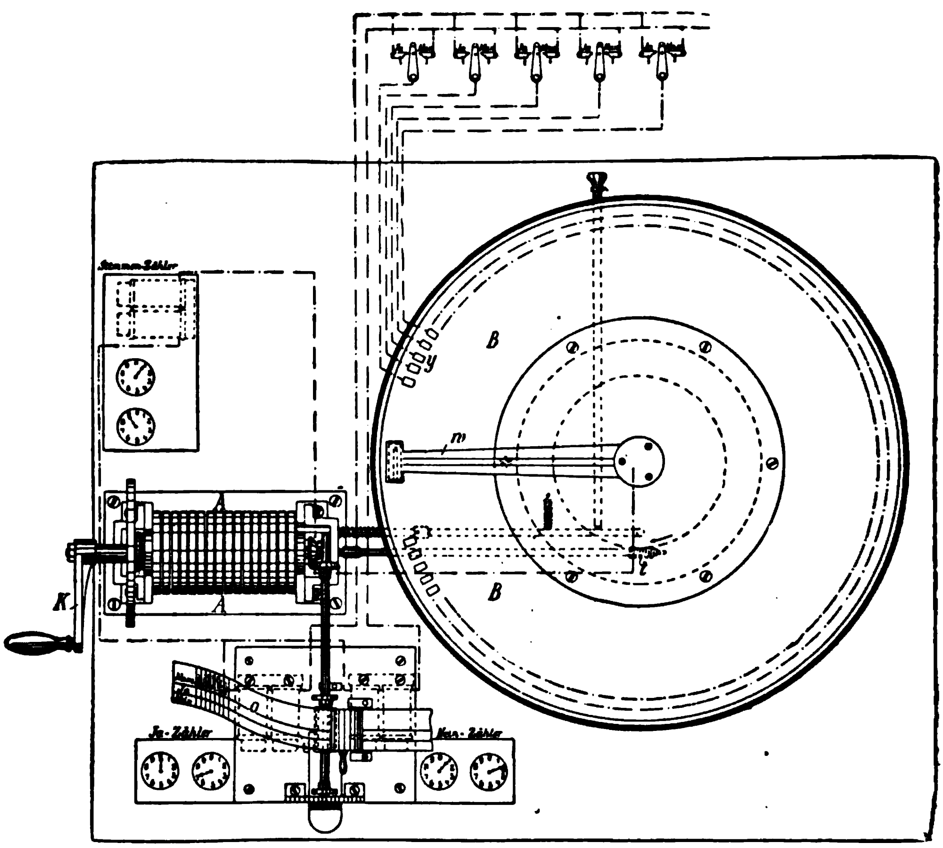
The way the voting takes place is that on the challenge of the President, each deputy goes to his place, and turns the voting lever to the right or left, according as he proposes to vote Aye or No.

To make this possible for the deputy concerned only and not for anybody else, the turning of the voting lever is effected by means of a key, which fits only into one place, and which is handed to the possessor of the same. When the president is satisfied that all voters have turned their voting levers then he causes a servant of the house to turn the handle marked with K until it comes to a stop, *i. e.*, with 300 voters about 20 times. By means of this operation which is effected in about half a minute the magneto inductor A is turned as often as there are voting places, and an equal number of electric alternating currents are thereby generated. By the revolution of the magneto inductor by means of the endless screw *t*, the lever *w* is turned simultaneously. At the end of this lever contact springs are fixed, which through the forward motion of the lever glide over the contacts *y* which are fixed on the periphery of the disc B. Each of these contacts *y* is connected by means of a special wire with the voting lever of each deputy. In

* Memorial to the House of Deputies, 1870.

this way by means of the above mentioned conductor two currents of alternate direction are led after each other to each voting lever. According to the position of the lever on Aye or No, these currents

Fig. 149.



are conducted to the Aye or No line, and set the magnets inserted in them in motion.

The armatures of these magnets carry colour or writing wheels which mark by the name of the respective deputy the Aye or No vote on the perforated paper strip marked with O. Simultaneously these armatures move the Aye and No counters connected with

the apparatus, which totalize the votes. In the inductor wire is further inserted the electro-magnet of the voting counters, which sums the number of all the alternating currents which have come in the circuit. As these currents can only appear, when the corresponding voting lever is turned to the right or left, and the electric circuit is thus completed, then the reading of this vote counter must be equal to the sum of the readings of the Aye and No counters, if the apparatus works faultlessly. All the mechanisms coming into use have been thoroughly tried in telegraph practice, so that there can be no doubt of the safe working of the apparatus if well carried out. The leading wires from the voting apparatus to the voting levers are laid together in a thin cable and placed under the floor, so that they are not in the way and cannot easily be injured. If it is desired a reprinting arrangement can be applied, with the help of which the voting list can in a very short time be mechanically manifolded as often as desired, so that a copy can be given to each deputy and the stenographers. Besides a large shutter could be combined with the apparatus, so as to make each deputy's vote visible to him from his place.

DESTRUCTION OF HOSTILE WAR SHIPS BY DIRIGIBLE TORPEDOES.*

The simplest, and to the seaman, the safest way of directing torpedoes is the following :—

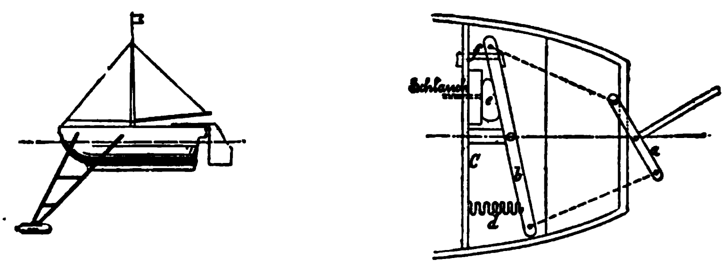
An ordinary sailing boat with suitable rigging (Fig. 150,) is provided with a spar of hoop iron directed downwards, which carries at a depth of from 6 to 7 feet below water level, the torpedo in the shape of a tube filled with dynamite. The torpedo must contain about 20 pounds of dynamite, and as it is advisable to leave about 1-3rd unfilled space must be able to contain about 30 pounds of water. It has in front an ordinary torpedo fuse, so that it explodes on striking a hostile ship.

* (Memorial to the Minister of War. 4th August, 1870.)

The rudder of the boat is so arranged that by means of a greater or less air pressure in an indiarubber bag it can be brought into any desired position and can be kept in it. For this purpose the rudder can be provided with a cross piece *a* (Fig. 151), to the ends of which thin cords are fixed, as is usual with small sailing-boats.

Inside the boat these cords are fixed to a somewhat longer lever *b*, the axis of rotation of which is connected with a piece of wood *c* fixed with struts in the boat. Between the lever *e* and the piece of wood *c* is fastened on the one side, a strong steel spring *d*, on the other side an indiarubber bag *e*. If the indiarubber is not

Figs. 150, 151.



blown out, the spring *d* presses back the lever *b*. The rudder is therefore turned quite to the left.

But if the indiarubber bag is blown out, it overcomes the strength of the spring, presses this together, and turns the rudder to the right. In place of the metal spring, there can be fastened on the same side as the bag a stretched indiarubber band between the lever *b* and the wooden piece *c*.

The indiarubber bag communicates with an indiarubber tube, such as are much in use with steam and water pipes. Also the usual fire hose can be used in its place but quite thin tubes of at most ½ inch diameter suffice. The indiarubber tube joins the boat best in the middle of the keel. This hose which may be many thousand feet long is coiled up like a ship's cable on land or on the boat or ship, from which the torpedo boat is to be sent so that it will pay out as required when the latter moves off. The end of the pipe is connected with the cylinder of a pump with piston or with another indiarubber bag of larger dimensions, which latter

lies between two strong planks, which can be pressed together at will by means of a lever or screw. By this pressing together or downward motion of the pump piston one can as desired make the air pressure in the indiarubber bag as great as one pleases, so as to give the rudder any desired position.

The operation should be so carried out, that with a favourable wind the torpedo boat is followed by a second larger boat which carries the coiled up pipe. This can either take place in the night or under circumstances when it appears to the hostile ship unlikely, that spies or pilots will quietly approach him.

At a distance of 800 to 1000 paces, the man in the torpedo boat would fix the sail firmly and jump overboard, so as to reach the second boat by a line. This latter would follow the torpedo boat slowly, and so keep it in the right course. At night a small closed light might be hoisted in the torpedo boat, only throwing a little light backwards, so that its course might always be observed. When the explosion has happened the following boat turns about, and thereby draws in the pipe, which is loosened from the torpedo boat by the explosion. As the pipe filled with air floats, it offers no considerable hindrance to the forward motion of the torpedo boat if the wind is not too light.

In case there is no wind, or the enemy cannot be approached with a boat I propose to fix two indiarubber tubes to a floating beam, (or a zinc tube), which carries the torpedo in the same way as the above mentioned boat.

Water is pumped through the one stronger tube, for which an ordinarily good fire engine on land will serve.

The second pipe which is fastened throughout its whole length to the first is filled with air as above and serves in the first place for steering, and in the second to maintain afloat the other filled with water. This torpedo is forced forward by the reaction of the water pumped through the pipe.

It is also possible, by an electric arrangement, so to steer a sailing or steam boat automatically that a course previously arranged by a compass may be maintained. But in the present hurried circumstances of time only quite simple arrangements are practicable. Indiarubber tubes and bags are to be obtained in any indiarubber works. If desired Siemens and Halske of Berlin will procure them.

AUTOMATIC ELECTRIC STEERING OF TORPEDO BOATS.*

The idea expressed at the conclusion of the previous article that it is possible to steer a ship automatically by means of an electric arrangement, was farther pursued by Dr. Werner Siemens and a construction worked out, which perfectly carries out the purpose as was already shown in November 1872 by trials on the Tegel lake with a small steam launch placed at his disposal by the Imperial Navy. This construction received its definite form (agreeing with the previous one in all essential points) in 1873 and very satisfactory results followed its completion in July 1874 in great trials on the Rummelsburger lake. In what follows this steering apparatus about which nothing was published at the time, is described according to materials preserved among the records of Siemens and Halske.

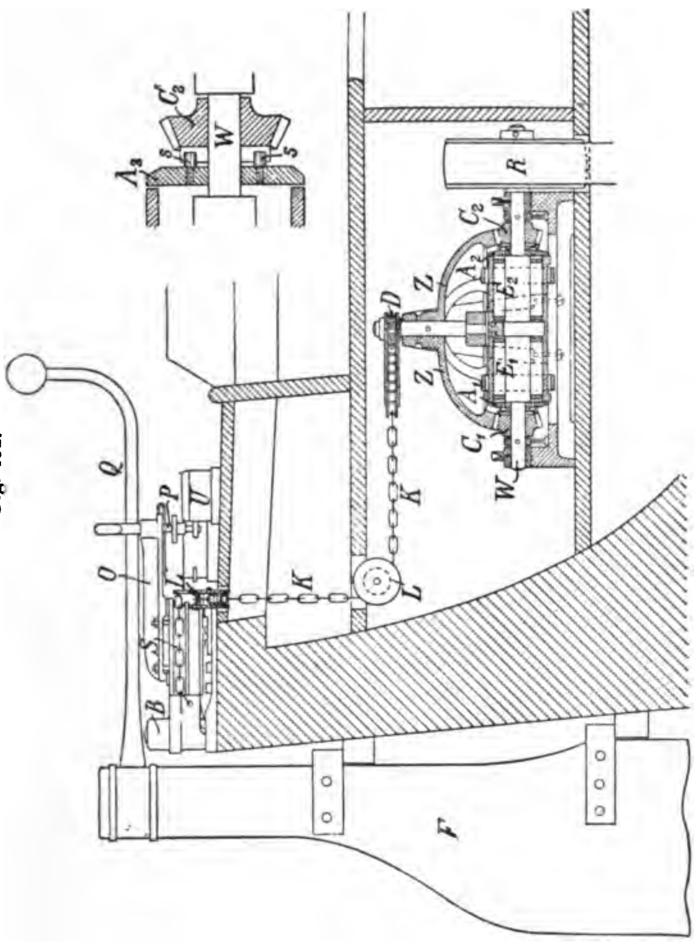
The essential part of the whole apparatus is an electrical coupling in the ship to be steered. This consists of two electro-magnets E_1 and E_2 lying near one another (Fig. 152) which are rigidly connected to a shaft W in horizontal bearings driven by the ship's engine.

Electrical contact for the current is made by sliding springs. The disc armatures A_1 A_2 of both electro-magnets run loose on the same shaft W and gear with two projecting pins *s* into lateral grooves of two conical wheels C_1 and C_2, opposite to them as may be clearly seen in the detailed plan Fig. 152, which are also loose on the shaft W. A third larger wheel Z, revolvable on a vertical axis gears into these wheels C_1, C_2. So long as neither of the electro-magnets is energized, neither of the two wheels C_1, C_2 takes part in the revolution of the shaft W. But if one of the two electro-magnets, for instance E, is energized, its disc armature A_1 becomes coupled to it, and thereby the wheel C_1 therefore also Z is set in motion in the corresponding direction. If on the contrary, a current is sent through the electro-magnet E_2, the wheel C_2 produces a revolution of the wheel Z in the opposite direction. The sprocket wheel D is firmly connected with the wheel Z lying opposite it; a chain K passed round this, leads over four rollers L to both ends

* 1872, 1874.

of the circumference of a sector S turning about the axis B and causes it to revolve towards one side or the other, according to the direction of revolution of the sprocket wheel D. An arm *o* rigidly

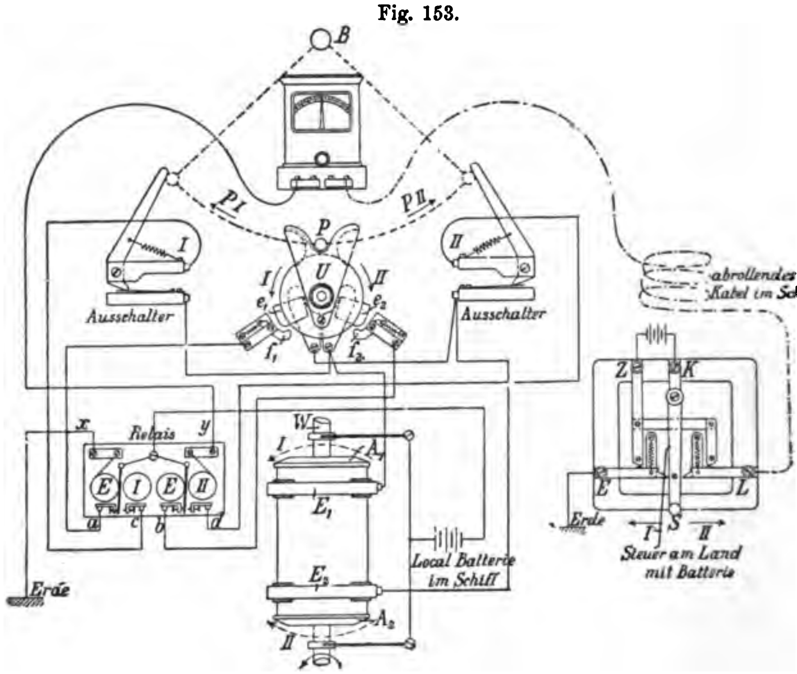
Fig. 152.



connected with the sector S, takes part in its movement, and a pin P at the end of this arm, through the upper bow-shaped part of which the tiller passes, causes a corresponding turning of the rudder F.

The ship to be steered, is always in conductive connection with the point from which it is to be steered, through a wire insulated with gutta-percha, which is payed out from it. A commutator set up at this point—shown in the diagram of connections Fig. 153 as "rudder on the land with battery"—allows the current of a battery joined up between the terminals K and Z to pass in one or other

Fig. 153.



direction through the insulated conductor or through a light cable and through a double polarized relay on the ship. In the position of rest, the two armature tongues of this relay lie on the contacts *a* and *b*. If the handle S of the rudder on land, moves in the direction of the arrow I, the tongue of the relay-electro-magnet I closes the contact *c*; by this means the current of a local battery placed in the ship, is sent through the electro-magnet E of the coupling, and thereby causes a corresponding turning of the rudder. Immediately after the beginning of this revolution, the above mentioned pin P as seen in Fig. 153 makes sliding contact between the two

metal pieces e_1 and f_1 through its action on a commutator U. The result is that immediately after the steering handle S has been moved back to its position of rest, therefore after the return of the armature tongue of the relay-electro-magnet I to the contact a, the current of the local battery in the ship is led through a and e_1 f_1, into the windings of the electro-magnet E_2 of the coupling, and a return motion of the rudder is brought about. The switches I and II shown in Fig. 153 prevent the rudder from overstepping the furthest admissible limits, as, on the pin P striking against the lever of this switch on exceeding these limits, the local circuit is interrupted, therefore the coupling is set free. It is further easily understood from Fig. 153 that the commutator U of the rudder, so long as the same is not designedly diverted from its place of rest, allows only very small oscillations to take place, since with each greater deflection one of the two contacts $e' f'$ or $e_2 f_2$ is closed, and through the coupling being thus brought into action, the return to the position of rest is effected.

It may also be remarked, that the insulated copper wire, forming the electric connection between ship and land, is not wound upon a drum, but is coiled up in the same way as sailors are accustomed to do with their cables. This is to diminish the moment of inertia and frictional resistance of the drum. As the coiled insulated wire runs out without friction from the ship, with a corresponding velocity, there is no tension of any kind produced in it. It can therefore be very thin and light, so that it does not influence at all the motion of the vessel and takes up only little room.

It is further to be noticed, that the electrical steering method described, acts so correctly and safely that it can be employed for steering from the bridge or any other place.

It may finally be mentioned, that it was also sought with success, to steer a ship automatically along a determined course by means of a magnet needle placed on it; in this case the magnet needle itself took the place of the above-mentioned handle S, making the necessary contacts for setting in motion the coupling, by its own deflections.

IMPROVEMENTS IN THE PRODUCTION AND USE OF MAGNETO-ELECTRIC CURRENTS.*

If such a form is given to the poles of a powerful electro-magnet or steel magnet, that they lie nearly opposite to one another in sufficiently large, flat or concentric surfaces, the magnet is to be considered as closed, which exercises externally hardly any or only a very slight action. If a suitably bent portion of a closed conductive circuit is moved through the space between the polar surfaces, a current appears in it, the strength of which is proportional to the surfaces passed over by the conductor between the polar surfaces, and to the strength of the whole magnetism produced in the magnet. If the whole of the space between the polar surfaces is filled with the insulated conducting wire—in the form of a coil of wire—there is obtained by the motion of this coil, the maximum of inductive action of which the magnet is capable; inversely the maximum of energy is obtained if an electric current is sent through such a coil.

This motion of a coil of wire suspended in a powerful ring-shaped magnetic field, can be made use of for all sorts of telegraphic purposes, especially for the construction of highly sensitive relays for very long submarine lines. To guard against vibrations of the coil, which might make the contacts insecure, its wire is wound on a thin metal cylinder, Aluminium being best, or the coil is externally surrounded with one; in this way a powerful damping is produced without the sensitiveness being reduced.

Fig. 154 shows a ground plan and a part cross section of an apparatus of the above described construction.

N and S are the two poles of a magnet; N′ is an iron-plate extension of the pole N with a cylindrical hole, through which the pole S projects. In the ring-shaped space between N′ and S, a coil of wire C hangs by two wire springs A which serve at the same time as conductors.

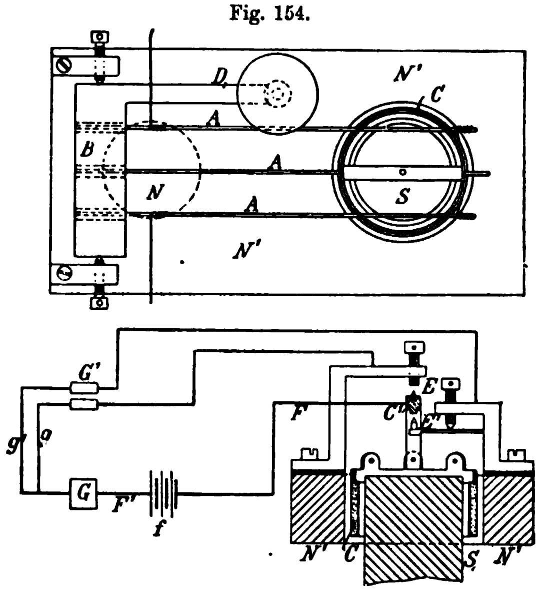
These springs are fixed, insulated in the piece B which can rotate between two points and can be so arranged between a set

* (English Patent, No. 1919 of the 25th June, 1872.) 1872.

screw and spring acting on the arm D, that the coil C hangs exactly vertical.

The middle one of the three springs A, serves as conductor to the metal body of the coil C. If the electric current is sent through the windings of the coil, the coil rises or sinks according to the direction of the current; alternating currents produce an up and down motion. The diagram contained in Fig. 154, gives an example how these motions can serve for telegraphic purposes. A

Fig. 154.



metal bow C′ resting on the coil C, carries a metal piece provided above with a point, and below with a flat surface, nearly opposite to which stand above the contact E with flat surfaces, below the contact E′ with a point. The bow C′ is connected through the middle wire spring A with one pole of a battery *f*, the second battery pole by means of a conductor F′ with a commutator G; from this, two conductors *g* and *g′* lead to the two divisions of a second commutator G′, which are on the other hand conductively connected also with the contact pieces E and E′. On rising the coil G therefore closes the circuit *f* F C′ E G′ *g* G F′ through the

contact E on sinking the circuit f F C′ E′ G, g' G F′ through the contact E′. The telegraph apparatus joined up to the arms g and g', therefore receive intermittent current from the battery f' if alternate currents are sent through the coil C. The two divisions of the commutator G′ can be connected and only one apparatus inserted between G and G′. If the current passing through the coil C ceases, this latter returns exactly to its position of rest.

The apparatus can also be so altered that the coil C swings in the horizontal direction by placing the magnet poles N and S

Fig. 155.

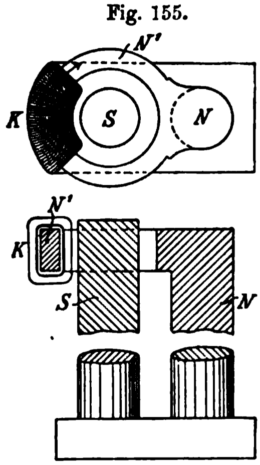
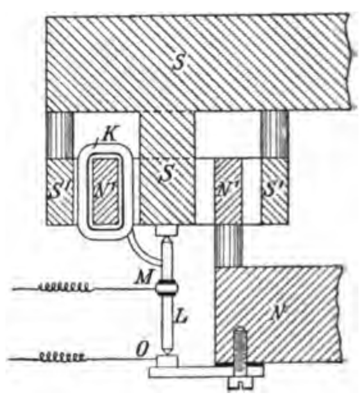


Fig. 156.



horizontally, and hanging the coil C from four threads, so that it is brought back to its position of rest by gravity.

Fig. 155 shows the diagram of an apparatus by which the motion of the coil of wire follows a circular course.

One magnet pole N is enlarged by a ring N′ which surrounds the other pole S. A cross wound coil of wire K freely movable along the ring, surrounds the ring N′. If an electrical current passes through it, it moves towards one side or the other, according to its direction; inversely currents are produced in it, when it is mechanically moved along the ring.

Fig. 156 shows an apparatus similar to the preceding one in full size. Here one magnet carries an annular addition N′, and the other pole, the cylinder S and the ring-shaped extension S′.

A coil of wire K wound on an ebonite or other non-magnetic material which is carried by a vertical axle L, surrounds the ring N′. One end of the winding of this coil is connected through the lower bearing of the axle L with the wire O, the other insulated as regards L with the wire M. If the axle L and with it the coil is set swinging, the conductors M and O, are traversed by alternate currents; if inversely alternate currents are sent through the coil K, they set the latter swinging around the axle L.

What I consider as new and my invention is:—

1. The apparatus shewn in Fig. 154, in which a coil of wire swinging in a magnetic field is set in motion by electric currents or produces electric currents by mechanical motion.

2. The way and means, shewn in Fig. 154, of using the motion of such a coil for closing local batteries.

3. Surrounding moving coils of wire in magnetic fields with a mantle of aluminium or other metal used for the purpose of damping.

4. The modification of the apparatus shewn in Fig. 154 by which the coil of wire is hung by threads and is movable in a horizontal direction.

5. The arrangement shewn in Fig. 156 in which a forward and backward motion is given to a coil of wire in a magnetic field.

SIEMENS AND HALSKE'S AUTOMATIC ELECTRIC LAMPS.*

Preface.—The automatic electric lamps described in the following, depend on the principle proposed by Werner Siemens, of differential regulation by main and shunt currents; the carrying out of the construction in its details to Mr. Von Hefner-Alteneck, for many years head of the designing office of the firm of Siemens & Halske.

The principle is the following: an electro-magnet with a few

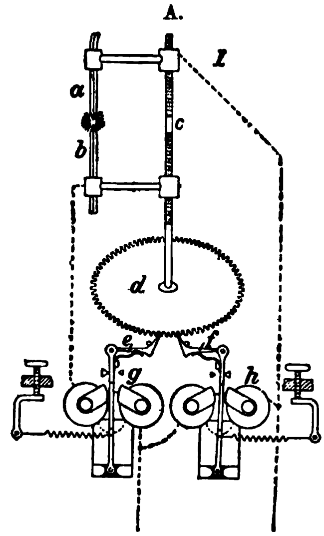
* (Abstracted from the English Patent, No. 2006 of 5th June, 1873.)

1873.

windings of thick wire is inserted in the main circuit, and a second with many windings of fine wire, in the shunt circuit to the arc. Both electro-magnets act on a differentially moving mechanism of such a kind, that the action of the main current removes the carbons from one another whilst the shunt current causes them to approach. At a certain determined distance of the carbons, there is rest; when the carbons are consumed further, the main current becomes weaker, and simultaneously the shunt current stronger.

Fig. 157.

A.



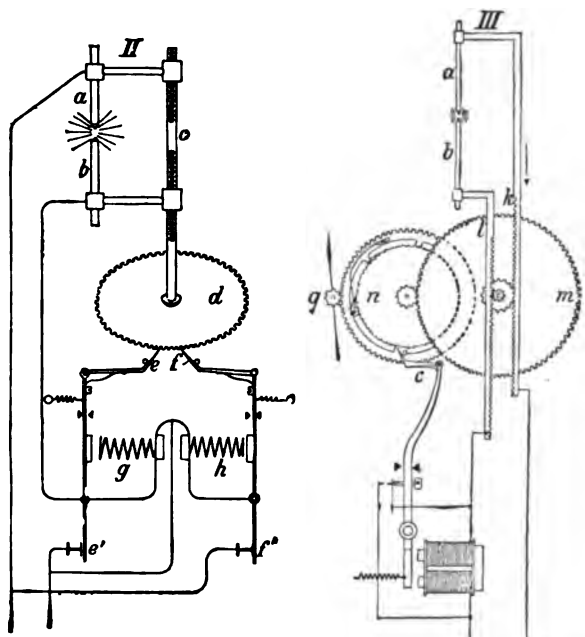
By the action of the latter, the carbons are again brought together. If the arc goes out, this action increases until the carbons touch; then the main current becomes too strong and removes the carbons from one another again until equilibrium is re-established.

Diagram I of Fig. 157 represents a lamp arranged for alternate currents. The carbon holders *a* and *b*, can be approached to or removed from one another, by turning a screw *c* provided with a right and left thread. The turning of this screw is effected by means of the toothed wheel *d* by two pawls *e* and *f* resting on the armature tongues of the polarized electro-magnets *g* and *h*; *g* is the electro-magnet lying in the main current, *h* that lying in the shunt

current to the arc. If the carbons *a* and *b* touch, and a current is sent through the lamp, the electro-magnet *h* at first remains without current, whilst *g* gets the full current and in consequence of this through the in and out motion of the tongue of its armature by means of the pawl *e*, the wheel *r* turns in such a direction, that the carbons remove apart. If in this way the resistance in the

Fig. 157.

B. C



main current increases to a certain extent, the electro-magnet *g* ceases to act, on the other hand the shunt current passing through the electro-magnets *h* becomes strong enough to set in oscillatory motion its armature with the pawl *f*, and thereby to turn back the wheel *d* in such a sense that the carbons again approach. The lamp thus automatically regulates itself for a determined length of the arc. In order that the inactive pawl may not hinder the turning of the wheel *d* brought about by the other, the pawls are raised out of the teeth of the wheel *d* by the under-running of

a peg on a sloping surface as soon as its armature teeth approach the rest stops.

The lamp represented in diagram II is for continuous currents. If the electro-magnet *g* lying in the main current attracts its armature, it closes the contact *e′* and thereby opens for the current a direct way past its windings to the arc. The fall of the armature thereby brought about passes the current anew through the electro-magnet, and this play is repeated until the arc becomes so great that the electro-magnet *h* lying in the shunt circuit receives current enough to attract its armature. This interrupts its own current by the opening of the contact *f′*, lets its armature fall again, therefore again receives the current and so forth ; the oscillatory motion of the pawl *f* set up thereby turns the wheel *d* in the sense that the arc again becomes smaller.

One of the two electro-magnets can be entirely done away with, when the preponderating weight of the upper carbon holder or a spring put in its place, serves to bring the carbons together. Diagram III Fig. 157 shows an arrangement of this kind. The carbon holders are carried by the toothed racks *k* and *l*, which gear into two drivers on the same axle, the diameters of which are as 1 to 2, when the lamp is arranged for continuous current. As is known with the use of continuous currents, the carbon connected with the positive pole burns about twice as quickly as the other ; when *k* therefore sinks, *l* must only rise half as quickly in order that the arc may maintain the same position.

The sinking of the upper carbon holder is made slow by a fly *q*, by means of the toothed wheels *m* and *n*. The electro-magnet lying in the main current has the task by the gearing of the pawl *c* on its armature tongue into the teeth of the wheel *n* to balance the sinking motion of the upper carbon holder, or it may be to change it into a rising one if the carbons come too close together. In order that in this arc the fly may not be turned backwards, its driving wheel is loose on its axle and only connected through a stop catch with the wheel *n*. For the rest, the forward and backward motion of the armature of the electro-magnet occurs by closing and opening a contact exactly as with the electro-magnet *g* in diagram II.

IMPROVEMENTS IN AUTOMATIC TELEGRAPH APPARATUS FOR SENDING AND RECEIVING MORSE WRITING, STEINHEIL WRITING, OR TYPE-PRINTING, USING EITHER DIRECT OR ALTERNATING CURRENTS.*

Note.—The Box-sender contained in the following patent specification is of Mr. von Hefner-Alteneck's construction.

The improvement in the sender consists in the first place, in one and the same apparatus serving for continuously setting up, telegraphing and taking apart again the type used for the automatic sending of the current, so that they can be used again in the sequence named. The types are formed of pins, (or otherwise suitably shaped pieces,) which are placed movable in the links of an endless chain, or arranged in the circular perimeter of a casing (box). The pins can be shifted either to both sides (for Steinheil writing)—in which case the pins pushed out on one side will subsequently serve for sending the positive current into the line, and those pushed out on the other side, the negative—or to one side only (as in Morse writing,) a pin protruded between two not pushed out represent a dot; two or three in succession not protruded, a smaller or greater space. The setting up of the type, *i.e.* the shifting of the pins into corresponding groups, is effected by depressing keys, one of which is provided for each sign occurring in telegraphy, and is correspondingly marked.

The requisite mechanical connection with the parts which in the first place strike against and shift the pins by their forward movement is in principle the same as was first used by Dr. W. Siemens in the key apparatus for perforating the paper strip formerly employed in automatic telegraphy; each of the keys is so connected with a metal plate that, on depressing the key, the latter is shifted.

As many of these metal plates are therefore provided, as there are keys, and as they move forward, they strike with their front edges against a number of other plates, which lie transversely close to the former ones, and which are so connected with the parts

* (Description for Belgian Patent, No. 32830, of 27th June, 1873.)

striking the pins, that always one pin on the chain or box is displaced from its normal position by the movement of each one of them. In order to obtain the requisite grouping by the displacement of the pins, the first named plates have their front edges filed out in such manner that on depressing a key they always strike only those transverse plates, which by their simultaneous forward movement cause the pushing out of the pins corresponding to the sign on the depressed key.

After each depression of a key, the pins pushed out by it, are withdrawn from the action of the keys, and the pins in their normal position are brought in place of them just in front of the part directly causing the pushing forward. We effect the necessary intermittent movement of a portion of the chain, or it may be the intermittent rotation of the box, either by the pressure on the keys itself, or by means of a spring or falling weight, which is set in motion for the necessary interval of time by the depression of the keys. In the former case the motion is effected by means of a spur wheel placed on the same axle as the box or the wheel carrying the chain, which is made to turn by means of a pawl actuated by a lever moved by the above-mentioned transverse plates. The position of the axis of this lever with respect to the transverse plates is so selected, that for long signs the lever is struck by a transverse plate lying nearer to its axis than for short signs, its stroke (since the transverse plates all move equally,) and therefore also the movement of the chain or box is correspondingly greater or smaller. These ratios are so proportioned, that the forward movement of the pins on each depression of a key corresponds exactly to the length of the sign simultaneously represented in type fills the prescribed interval.

In the other case, where on the depression of the keys the movements in question have only to be released, a detent, which in the position of rest holds the chain-wheel or the box fast to a spur-wheel fixed on the same axle with it, is allowed, when the pin brought furthest forward by the depression of a key runs out, to rise out of the teeth of the spur wheel on to an inclined plane filed out of the detent. The said inclined plane is wider than the space occurring within a signal, which in this case is represented as is known by pins not pushed forward or wanting. The detent cannot again catch into gear until by the action of the driving

weight, (or spring,) the whole sign has passed under the inclined plane, and including the prescribed interval in consequence of a further corresponding widening of the latter.

When the pins are pushed out on both sides, the detent carries two inclined planes, one or other of which comes into action, according as the first and the last of the pushed out pins has protruded on the one or the other side.

The parts which immediately effect by their forward motion the displacement of the pins, are given the form of round pushers, and they are so guided at their front end that they can get out of the way sideways when the movement of the row of pins begins, and when the key is depressed, that they do not strike against the pins not pushed out, thereby checking the said movement.

As regards the manner in which the prepared signs in the form of pushed out pins suffice for automatic telegraphing, the sender presents certain differences, according as it is constructed with an endless chain or a box as carrier for the pins.

For the production of the spaces between the separate words, a special key is provided without designation, which is connected mechanically with the setting wheel or the box in such a way that these are turned through the corresponding angle when this key is depressed, without a pin being pushed forward.

In the chain sender, the endless chain, after it leaves the wheel, on which the setting up of the type is effected in the manner described, is led over a second toothed wheel (sending wheel), which brings forward a portion of the chain set with type with uniform speed, as soon as the tension of the portion of the chain hanging down between the two wheels allows it, which slackens in consequence of the intermittent pushing on of the other wheel. The uniform rotation of the sending wheel requisite for this purpose is produced either by a special clockwork with fly and weight, or by the driving action of a spring, or it is effected automatically by the movement of the preparatory mechanism. In the latter modification the clockwork of the sending wheel is in connection with the setting up wheel through a relatively weak spring, one end of which is attached to the axle of the setting up wheel, and the other end to the first wheel of the clockwork rotating loose on this axle, so that the intermittent rotation of the setting up wheel described above stretches the spring. We shall return later to

the movement of the current sending mechanism produced in a similar way.

In order to send the current to line by means of the pins pushed forward, in some circumstances the contacts required for this can be made by the pins pushed forward themselves, if they form part of the circuit, and in their uniform movement on the sending wheel of the chain sender strike against a metal spring with oblique surface, which is also in the circuit, which might then also serve at the same time for bringing back the pins into their normal position. We prefer, however, to allow the pins pushed forward to strike against the bevelled ends of one, or it may be two contact levers, which then effect the contacts in a way to be described subsequently by means of the oscillatory movement thus produced. After the endless chain has passed the contact lever, it is led back between inclined planes or rollers, by which the pins pushed forward are brought back to their normal position, and then it returns to the setting up wheel.

Naturally the chain is considerably longer than the path which it has to traverse. According as the operator works the signs on the keyboard, more quickly or more slowly, than others are simultaneously telegraphed on the sending wheel, (which speed can however be regulated at will by adjusting the vanes of the fly,) the portion of the chain set with type lying in front of the sending wheel, will grow, and in consequence the operator must, within a certain limit corresponding to the surplus length of chain, suit the speed with which he works the keys to the speed, dependent on the position of the fly, with which the telegraphing is effected.

In the box-sender, in which, as already mentioned, the movable pins are on the circumference of a box, in place of the contact lever, there is a pointer with a springy obliquely truncated point, which trails over the pins pushed forward, which are rounded on the inside. Its oscillatory motion thus produced is transmitted to the special contact lever pivotted rigidly to the frame by a small bell-crank lever pivotted on the pointer, which, by means of a cut out slot, acts with a to and fro motion on a pin or any other suitable mechanism, lying in a central boring of the axle of the pointer and projecting above the pivot of the latter. The box itself rotates loose around the axle of the pointer, while on the contrary, besides

the pointer there are firmly fixed on the same axle a toothed wheel placed inside the box, which gears with or without further toothed wheel gearing in the pinion or the endless screw of a fly pivotted rigidly to the box, and further the one end of a sufficiently tightened clockspring, the other end of which is fastened to the frame.

In the position of rest, this spring holds the pointer against a stop, which lies just behind the place where the displacement of the pins occurs. The intermittent rotation of the box brought about in one of the described ways by the depression of a key withdraws the pointer from this stop, and thus winds up the spring further. Whilst this latter sets in rotation about its axis the fly in the box through the wheel lying inside the box, it brings the pointer back against the stop, when the latter trails over the pins pushed forward and by the movement of the contact lever communicates their meaning to the distant station.

The pointer therefore participates in the intermittent rotation of the box, without impairing its uniform backward movement relatively to the row of pins, which is caused by the spring and is regulated as regards its speed by the fly in the box, which is moreover adjustable.

According as the operator works the signs on the keys more quickly or more slowly, the intermittent forward movement, or the uniform backward movement of the pointer relatively to the box preponderates, the pointer on the whole will therefore recede from its stop or approach it. The actual movement of the pointer may be rather less than a complete revolution, and an arrangement can be introduced which sounds a gong when the operator is about to overstep the allowable gap between the setting up and the automatic telegraphing of the types.

As with the chain-sender, the pushed out pins are brought back into their normal position by inclined planes or rollers, after their protrusion has fulfilled its purpose. If the pins are pushed forward out of their normal position towards both sides, the chief axis carries two pointers, which lie in the same plane on both sides of the box.

There still remains to be stated, in what way we arrange the contacts themselves. The simplest form of this is, that the contact lever should carry a spring tongue tipped with platinum, which, when the lever oscillates, plays with very little clearance

between two insulated contact screws. This arrangement together with the plan of connections employed with it corresponds to that of the ordinary Morse key. In another arrangement we produce the contacts by making the free end of the contact lever fork shaped, and allow it to abut from two sides against the middle of an originally straight spring, the two ends of which rest against abutments pressing against each other with a strong pressure, and the middle of which in consequence of this pressure bulges out so far towards the one or the other side, as is permitted by the two stops which make contact with the spring. It only requires a slight shock by one of the prongs of the fork against this bulging out, for the spring to be brought away from the one stop and beyond its straight middle position, and then to be laid with a sharp blow against the other stop of itself in consequence of the pressure exerted on it in the direction of its length.

The contact of the fork prongs of the contact lever with the spring is only temporary on each stroke of the former, and, if the fork prongs are insulated from each other, and the one is connected with the positive pole and the other with the negative pole of a battery put to earth at its middle point, they can be used to give shortened alternate currents with the use of Morse signs, or with other suitable connections for the discharge of the line, &c.

Instead of the springs with their ends pressed against each other the often employed arrangement of a lever with a spring passing over a stone with a sharp edge, or a roller can be used, or a similar contrivance. In certain circumstances we prefer, while still retaining the simplest form of contact first described, to effect the shortening of the variously long currents starting from the latter, to an equal interval of time by the following arrangement. To the conductor starting from the contact lever of the sender a shunt is connected to earth of correspondingly high resistance, and in this the winding of an electro-magnet is joined up. By the attraction of an armature lying in front, which results from overcoming an adjustable spring acting against this motion, the electro-magnet interrupts a contact, which is joined up in the line between the armature connected with the further extension of the latter and its stop.

The two contact screws, between which the tongue of the contact lever on the sender plays, are connected respectively with the

positive and negative poles of batteries, the opposite poles of which are connected to earth. If the contact tongue rests permanently on one or other contact screw, a continuous current traverses the windings of the electro-magnet; this keeps its armature attracted and the circuit is broken. If the contact tongue alters its position the direction of the current in the windings of the electro-magnet is simultaneously altered.

By the change of polarity consequently caused, the electro-magnet lets go its armature for a moment only, to attract it again in consequence of the polarity which is again produced in the opposite direction. Therefore, with each stroke of the contact lever only a short current passes into the line, however long this may be kept in its newly gained position.

The attracted electro-magnet armature also lies naturally against a stop, and this can also be converted into a contact for the back discharge of the line, for instance, if it is connected to earth.

We also employ this method of shortening unequally long currents of alternate direction to an equal length in connection with every kind of alternate current key and with relays, especially on submarine or long underground lines.

Instead, as above described, of forwarding the messages in Morse or Steinheil writing characters, by means of the automatic chain or box writer, and of receiving them at the distant station by means of a correspondingly constructed single or double writer, we employ them in connection with a printing apparatus constructed by us for sending and receiving printed writing.

This is generally effected in such a way that by means of the currents which are produced in suitable manner, number and sequence by the depression of a key, a type wheel is turned forward up to the letter represented by the depressed key, that then during the pause which separates the currents belonging to two letters, a printing mechanism is set in action, the printing is carried out, and then the type wheel is released for a moment from the actuating mechanism and the action of a spring, &c., is substituted, which effects its retardation, or advance to its position of rest, whilst simultaneously the paper strip after being printed is carried forward so far that the place for another letter is free. This can be effected in the same way as in every pointer telegraph (step by step motion) by a succession of direct or alternative currents,

which are equal to the number of steps which the type wheel has to pass over back to the desired letter.

We prefer, however, to diminish considerably the number of necessary currents by allowing the type wheel to move forward a determined greater number of steps, *i.e.*, of consecutive letters, by a short current of one direction, while by a short current in the opposite direction only by one step. We effect this by putting the printing mechanism in connection with a so called planet wheel, which gears into two wheels, one of which is actuated by positive the other by negative currents, and with different velocity. Or we arrange the printing type on an axle of less diameter instead of on the periphery of a wheel and by means of the mechanism arrange that the currents in one direction turn the axle, those in the other, on the contrary, displace it in the direction of its axis. Or finally, we arrange type suitably on a flat plate and shift this plate in one direction by positive in the other by negative currents.

After accomplishing the printing, the cylinder or plate, as in the first described case of the type wheel, is left free a moment, and by suitably arranged springs is drawn backward or forward into the position of rest. We hold the type wheel in this position of rest without permitting it to start back from the stop by the wheel at the last moment of its motion striking a spring lever, which moves a little by the blow of the wheel, and thereby pushes out an obstacle to the backward motion of the wheel, which immediately afterwards is removed again by the springiness of the stop. If, on the contrary, the type wheel is drawn forward instead of backward, the stop point of the wheel presses back just before reaching the position of rest the slanting surface of an elastic tooth which opposes its motion, and thereby simultaneously presses forward a stop connected with this tooth in the circle of motion of the wheel. In both cases the wheel is forcibly detained in the position of rest.

The printing itself we effect by a local magnet, with or without the help of clockwork. We regulate the local current which energizes this magnet at the moment the type wheel stops, by one of the means employed in the automatic printing telegraph. But we prefer the use of a so called rattle contact. This consists of a light lever, which is slightly raised by the passing under it of each tooth of a wheel connected with the type wheel, and in this position strikes a spring contact, whereby the current of the local

magnet is closed. As the contact on the forward motion of the wheel is only a momentary one in consequence of the trembling of the spring contact, the current does not last long enough for adequate magnetization of the local magnet. But if the wheel stands still, the contact lever remains on the top of the tooth, and closes the circuit sufficiently long, owing to the then continuous contact with the contact spring resting on it, to effect the attraction. As soon, however, as the attraction of the armature is effected, the contact lever is attracted a little back by it, and therefore falls back from the top of the tooth and breaks the circuit, by which means the type wheel again becomes free after the printing has been effected, and is drawn forwards or backwards to its position of rest.

Instead of drawing the type wheel back, we let it turn forward in its original direction into its position of rest against a stop momentarily pushed forward for its arrest by the printing mechanism. This last arrangement has the advantage that the inking of the types can be effected in the usual way by an inking wheel, whereas with the first described way, the printing must be carried out with the help of transfer paper. Instead of carrying out the preparation of the messages by means of the chain or box writer simultaneously with their telegraphing, we can also prepare the messages in a perforated paper strip with Siemens and Halske's key perforator and dispatch the messages so prepared with the help of a clockwork (current sender) which draws the paper strip through the springs, brushes or rollers producing the contact.

Instead of communicating different movements in the same or opposite direction to the part carrying the type in the manner described by the action of currents of different direction, and of bringing a certain type to the printing position by a suitable combination of such currents, we can also allow the currents (with or without the help of clockwork) to act on two separate pointers in such a way that each positive current moves one pointer, each negative current the other pointer one step. After each step the pointers come in contact with metal stops or springs, which are fixed insulated on the field of the pointers in such a way that they can be trailed over by the respective moving pointers, without thereby stopping them. All the pins, which can be simultaneously touched by their respective pointers, are connected with each other

by leading wires, the number of which is very great in comparison with the number of pins. In each of these wires the windings of one electro-magnet are connected up, which as soon as it is energized by a local current, brings a stamp with a determined sign to the printing place and prints it on a paper strip, then brings both pointers to their position of rest by means of a mechanism used in common by all the electro-magnets and again draws forward the paper strip by a corresponding piece.

The pointers are in connection with the opposite poles of a local battery; as soon, therefore, as they touch any two pins simultaneously for any length of time they allow a current in the corresponding wire connecting the two pins, which with the assistance of the corresponding electro-magnet in circuit brings about the printing of a sign, the backward movement of the pointer to its position of rest, and the necessary advance of the paper. As the short line currents, which effect the placing of the pointers on two corresponding pins, follow quickly on one another, only quite short currents can arise in some of the local lines with the movement of one or other pointer before the desired position is reached, and these are not strong enough to attract the electro-magnet and to print wrong signs.

We consider as new and as our special invention—

1. The automatic preparation of messages to be dispatched, by a suitable shifting of pins, which are placed in endless chains, or on the circumference of boxes (cylindrical barrels).

2. Specially the simultaneous shifting of all the pins necessary for the automatic bringing forward of a telegraphic writing sign, through one depression of a key by means of mechanism similar to that which has been used in Siemens and Halske's so called key perforator.

3. The intermittent advance of the chain or box in such a way, that after each depression of a key, pins not pushed forward with the necessary spaces are brought in front of the thrusters controlled by the keys without loss of time.

4. The simultaneous automatic telegraphing of the prepared messages, following the preparation, with the help of a weight or spiral spring, which is either independently wound up or is wound up by the intermittent advancing chain or box, and then in its turn moves the sending mechanism.

5. The automatic pushing back of the pins into their normal position after the telegraphing.

6. The arrangement described of allowing the contact making mechanism rotating regularly and continuously in the box to take part in the intermittent movement of the box without disturbing their relative speed.

7. The contact arrangement as described, which depends on a flat spring (in certain cases two) exposed in the direction of its length to a powerful elastic pressure, whereby the spring is pressed against one or other of the side stops, when it is removed by pressure or by a blow from the other position of rest.

8. The arrangement connected therewith by which short alternate currents are sent into the line, and the latter is discharged after each current.

9. The arrangement described, by which currents of different direction and different length can be adjusted to the same length by the action of an electro-magnet, and the line can be discharged in addition.

10. The arrangement described of automatic current senders with type wheels, cylinders or discs, which are drawn forward or backward after the completion of each printing into their position of rest.

11. The reduction of the number of the currents necessary for the correct adjustment of the printing types concerned, by the use of positive and negative currents, in such a way that through their proper combination the printing wheel or the printing axle or disc is correctly placed for printing by the use of the smallest possible number of currents. Specially the arrangement described by which the printing wheel is moved by a current in one direction by three, four or more letters, and by a current of opposite direction on the contrary by one step forwards.

12. The rattle contact as described.

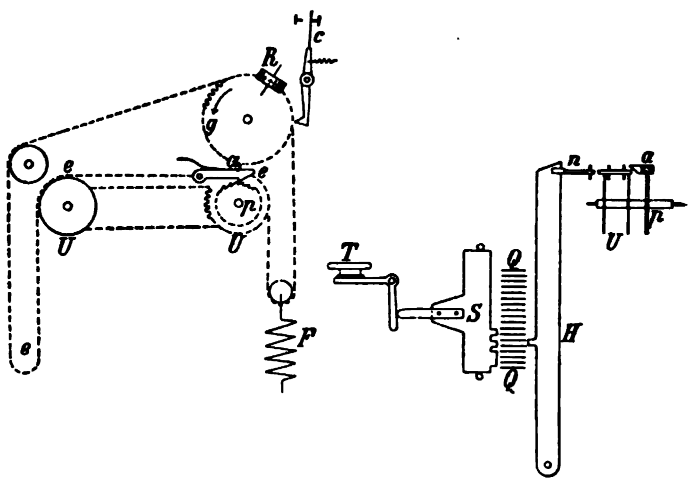
13. The sequence of letters, types, &c. on the printing wheel in such a way, that those which occur more frequently are brought by a smaller number of currents to the printing place, than those which occur more seldom.

14. The arrangement described of the type printer, in which the necessary movements for printing each sign are carried out by a special electro-magnet, which is set in action by a determined simultaneous position of two pointers.

The accompanying drawings show the sender diagrammatically in some of its above described modifications, without reference to dimensions, and with the omission of all unessential parts, or such as obscure the view.

Of the keys one only is always shown (T), and also only one of the filed out plates (S), movable by the depression of the key. As understood, the transverse pieces (QQ) lying in front of the

Fig. 158.

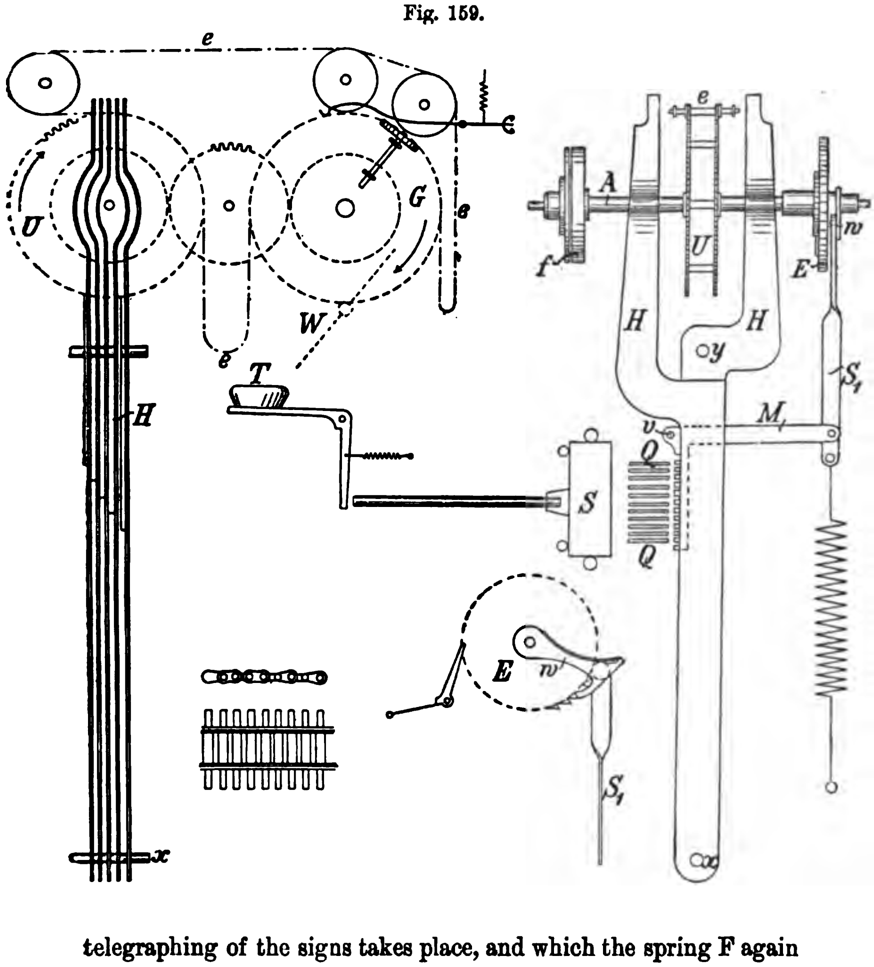


plates (S) appear foreshortened to lines, and most of the parts (HH) for transmitting the pushing of the transverse pieces to the pins, are equally assumed as taken off. The contact levers are denoted by C, which in the sketch of the sender are shown in their simplest form, by R the rollers or oblique surfaces effecting the pushing back of the pins.

Fig. 158 shows the sender for Morse writing with an endless chain, and therefore with pins movable towards one side only, and in this case driven by clockwork. The shifting of the pins is carried out in the portion of the chain *e e* lying straight between the setting up wheels UU, which rotate in fixed relation to one another; *a* represents the pawl, with oblique surface filed away sideways, which is raised out of the teeth of the ratchet wheel *p*, by the passing of the pins, whence in consequence of the pull

of the spring F the chain is set in motion, and remains so until the last pin pushed forward has passed under the oblique surface of the pawl, *g* is the sending wheel turned by clockwork with uniform velocity in the direction of the arrow, at which the

Fig. 159.

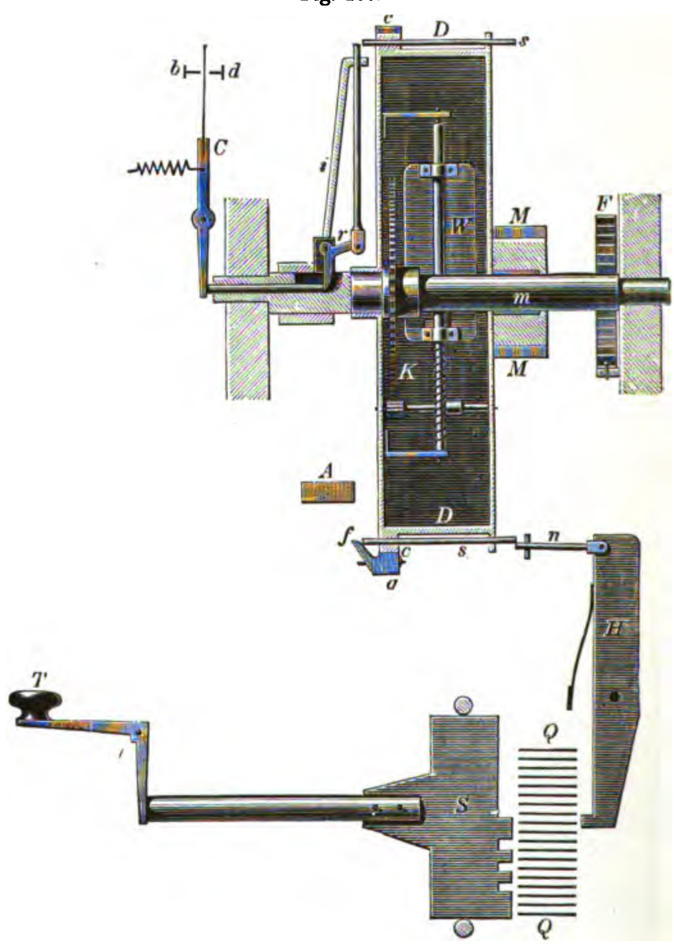


telegraphing of the signs takes place, and which the spring F again winds up.

Fig. 159 represents a chain sender in which all motions originate from the depression of the key, and which is arranged for sending

currents in two directions and in any desired grouping (Steinheil writing type printing) in which also the pins on the chains are

Fig. 160.

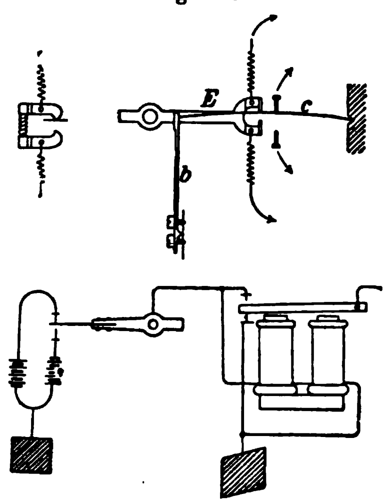


shifted to both sides. Accordingly the levers H H, transferring the shifting of the transverse pieces Q Q to the pins on the chain, have differently situated pivots x and y, according as the shifting of the transverse piece is transferred as right or left shifting to the

pin found at the corresponding place through the lever standing in connection with it.

M is the lever described with its pivot at *v* situated peculiarly to the transverse plates, which turns the setting up wheel U through a correspondingly large angle, by its varyingly large stroke, according to the lengths of the sign simultaneously pressed down by a key, by means of the connecting bar S and the pawl *w* gearing into the ratchet E borne by the axis A of the setting up wheel. This intermittent rotation of the axis of the setting-up wheel

Fig. 161.



winds up a watch spring fixed at *f*, by which the sending wheel C is set in rotation with a velocity regulated by the fly W.

Fig. 160 represents the box sender for Morse writing, driven by a weight, which can naturally be replaced by a spring motion, D represents the loose box capable of turning about the axle *m*, on the circumference of which the pins are placed, *a* the pawl with oblique surfaces which is raised by the projecting pins for the necessary time out of the tooth rim A, *i* the pointer with the pliable points trailing over the pins, K the toothed wheel firmly fixed on the pointer axle M, lying inside the box, which gears with the fly W firmly pivotted to the box which takes the driving force of the weight, F the spring, which is wound up by the step-by-

step motion of the box and which brings about the jumping back of the pointer *i* against the stop, on the rotation of the fly W.

Fig. 161 shows in its upper half the contact arrangement described with the contact spring *c* bulged in the middle by the pressure of the spring *b*, and with the end E of a contact lever, projecting into the insulated fork prongs. Those points which are connected up in the circuit and can be utilized with corresponding connection according to the corresponding contact, are represented by the arrows flying from them. The lower portion of Fig. 161 represents the described arrangement and connection, with the application of a special electro-magnet for shortening the currents sent forth from the contact lever, of a sender of alternating direction and variable duration.

IMPROVED METHOD OF CABLE SPEAKING.*

The object of this invention is the improvement of contrivances for the quick transmission of telegraphic signals through long submarine or underground lines. For this purpose I so arrange a battery at both ends of the line between the line and the earth, that a continuous current of similar direction passes through the cable. Then, by the insertion of suitable resistances, I arrange that the electric potential is nil, either at the beginning of the line or in the middle of it. In the first case the relay is placed between the end of the line and the earth, in the second, between the end of the line and a middle element of the battery connected to the latter. In both cases by a proper adjustment of the resistances inserted, no current passes through the relay as long as the current passing through the cable, remains constant. But as soon as the electrical potential increases or diminishes at the sending end of the line, a positive or negative current passes through the windings of the relay and sets it in activity. As the cable ends are in conductive connection with the earth through their batteries, after each fluctuation of the charge which takes place, equilibrium is again

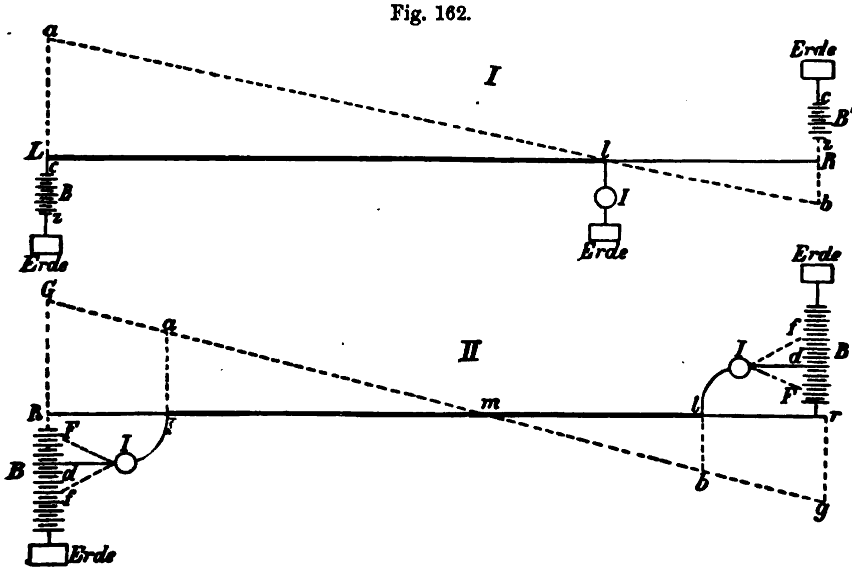
* (English Patent, No. 1307, of 16th April, 1874.) 1874.

brought about. An essential advantage of the contrivance is, that the cable always remains charged in the same sense in its whole extent, whereby the speed of transmission of the signals through the cable increases, and the latter itself is better preserved.

Fig. 162 gives a diagram of the two arrangements used by me.

In diagram I the line L *l* represents the cable, *l* R is a resistance. The line *a l b* represents the fall of potential existing at each point of the line according to Ohm's law, when the E M F of

Fig. 162.



the batteries B and B′ is represented by the ordinates L *a* and R *b*. A current only passes through the relay I inserted between the point *l* of zero potential and the earth, when the potential of the initial point L of the cable is altered. This alteration I effect either by the insertion or removal of resistance between the battery pole not connected to earth and the cable, or by altering the strength of the battery, or by inserting permanently between the battery and cable, a corresponding fixed constant resistance and bringing the cable itself alternately in conductive connection with a properly charged and a discharged condenser of suitable capacity, thereby giving to, or withdrawing from, the charge of

the cable a correctly measured quantity of electricity as most convenient for the production of distinct and quick signals. To strengthen the action of the relay, I allow the resistance *l* R to consist, for the most part, of one winding wire of a bifilar-wrapped coil of wire with movable iron core. The second wound wire of this coil of wire, is connected at the battery end with the earth, at the other end with *l*; the induction currents existing in it strengthen the motion of the relay and make them at the same time more exact, in that they shorten the current passing through the relay. The same result can also be obtained by the insertion of condensers and resistances between the relay and earth.

In the diagram II the point of zero potential M, lies in the middle of the cable in case this is faultless. But if the cable has an injured place of faulty insulation, the point of zero potential is so displaced by a suitable choice of resistances R L and *l r*, that it coincides with the faulty place, therefore no permanent current passes through the latter. The relays are in this arrangement inserted between the end of the cable and such points of the permanently inserted battery B B, that the E M F of both portions of the battery vary as the resistances R L and *r l*, in which case no current passes through the relay. As to the rest in this arrangement, the same dispositions exist as in arrangement I.

The arrangement II can also be used to determine with exactness the position of a fault in the cable, by replacing the relay by a sensitive galvanoscope; and inserting or withdrawing resistances on both sides until both galvanoscopes are without current. From the resistances so necessary, the distance of the fault from the middle of the cable, is given. This method has the further advantage, that the polarization of the fault has not to be taken into account, as at the moment that both galvanoscopes are without current, the point of zero potential of the cable coincides with the place of the fault.

I consider as my invention :—

1. The described method of letting continuous similarly directed currents pass through submarine or underground lines by means of batteries and inserting the receiving apparatus in currentless branches which are formed of proper combinations of resistances.

2. The production of currents of alternate direction in the

receiving apparatus by altering the potential of the distant cable end.

3. The described arrangement of induction resistances for strengthening and shortening the signals sent through the line.

ELECTRIC LIGHT.*

Several articles on the electric light in these pages, written not without knowledge of the subject, compel me to write a few lines in correction. I am specially compelled to do this on account of the concluding sentence of the article on the Gramme machine in No. 94 of this journal, in which the German love of justice is invoked in order duly to acknowledge the prominent merit of M. Gramme, whilst the German performances in the same department are only slightly noticed, and in another article, when an imitation of the Gramme machines by an Elberfeld mechanic was described, this gentleman's work is commended.

It is first necessary, to make clear the difference between magneto-electric and dynamo-electric current generators, as they are frequently confounded, and false conclusions are thus often arrived at.

Magneto-electric current generators or machines, was the name given to machines constructed by Pixii, Saxton, and many others, after the discovery of magnetic induction by Faraday, in which steel magnets were the only source of the current produced, before the poles of which electro-magnets were passed, or on which coils of wire were pushed to and fro. In opposition to the magneto-electric machines in which the electric current is generated by existing magnetism by means of work expended, stand the electro-magnetic machines, in which work is produced by existing electric current, with the help of the electro-magnetism produced by it. Such magneto-electric machines have the disadvantage that the

* (Elberfeld Gazette, April, 1877.) 1877.

work of the machines does not increase in proportion with their dimensions, as the steel magnets mutually weaken each other. Nevertheless, the Alliance Co. in Paris, succeeded in making magneto-electric machines, which served for the production of the electric arc light, and are also still used for electric lighting. These machines did not find further application, on the ground that, too great masses of steel, iron and copper wire were necessary in order to produce powerful action, whereby they became too heavy and costly. I succeeded to a certain extent in diminishing this disadvantage by the construction of the rotary cylinder armature, which has since obtained universal application in electrical engineering, and in manufacturing with its help powerful magneto-electric machines of much smaller dimensions. Wilde in England made a yet further step in advance, by combining two machines made on my system, of which the larger was provided with an electro-magnet instead of a steel magnet. If both cylinder armatures were rotated by a motor, and the current from the small magneto-electric machine passed through the windings of the large electro-magnet, this became powerfully magnetic, and produced very powerful currents in the windings of the rotating large cylinder magnet.

The technical knowledge of the production of electric currents by means of mechanical power had extended thus far, when I succeeded, in the autumn of 1866, in obviating entirely the need of steel magnets. The well-known fact that the electric current driving an electro-magnetic machine is considerably weakened by the induced currents produced in the windings of the electro-magnets, made it appear probable to me that by driving a properly constructed electro-magnetic machine backwards, the slight magnetism remaining in the electro-magnets must be considerably increased, since the induced currents are then produced in the same direction as those due to the existing magnetism, therefore, current and magnetism must simultaneously increase up to the limit of the magnetic maximum of the iron. Experience confirmed my conjecture. I called this new kind of current producing machine dynamo-electric, as by it mechanical force is directly changed into electric currents, whilst the magnetism only appears as an intermediate product, not as the real source of the current produced.

A few weeks after, on the 17th January, 1867, I had brought before the Royal Academy of Sciences the explanation of the principle of the dynamo-electric machine. Professor Wheatstone also published the same idea in England without knowing of my work. However, according to the general rule in science, the first publication gives priority, and as I had already shown in December, 1866, to several scientists and engineers of Berlin a dynamo-electric machine in action, the system of dynamo-electric machines is an undoubted and exclusively German invention. Of course the form of carrying out the dynamo-electric principle can be considerably varied.

Mr. Ladd, of England, exhibited in the Paris Exhibition of 1867 an almost exact copy of my dynamo-electric machine, with cylinder magnets, without mentioning the origin of it. Mr. Gramme, in Paris, subsequently treated both me and Mr. Pacinotti, the discoverer of the falsely-so-called Gramme ring, in the same way.

To Mr. Gramme belongs the acknowledged credit of having improved the Pacinotti magneto-electric machine, which he (Pacinotti) had already described in the year 1864 in the "Nuovo Cimento," but which had been forgotten again, and by replacing the steel magnet by an electro-magnet inserted in the circuit, of having changed it into a dynamo-electric machine. His invention, however, is narrowed to this combination.

The Pacinotti ring is so far unfavourable that only the outer portions of its windings generate current, whilst the portions of it lying inside the ring, hence one half of the surrounding wire, have no effect. Our Herr v. Hefner Alteneck has entirely overcome this disadvantage by means of a combination, understood only with difficulty without a drawing, of exclusively external windings of the ring, or in place of this of a massive cylindrical iron core. Such dynamo-electric machines were already exhibited in the Vienna Exhibition of 1873 by my firm (Siemens and Halske), and have since been constructed by them in great numbers.

The advantage of this machine over that of Gramme consists, as already stated, in that nearly the whole of the wire in motion acts inductively, so that such a machine produces nearly double the lighting effect of a Gramme machine of the same size. By means

of comparative experiments carried out in England and Brussels this advantage of our machine is positively confirmed.

Not only the discovery but also the best construction of the dynamo-electric machine can, therefore, with full right be claimed for Germany.

This is also true as regards electric lamps, of which only the French Serrin has been mentioned in the articles of this journal on electric light. The new lamps produced by my firm differ principally from the French in that the carbons are separated from one another by means of an automatically acting electro-magnet, in place of clockwork, whilst the weight of the carbon itself and its carrier brings them together. The advantages of these German lamps are everywhere recognized. Notwithstanding the above-mentioned essential improvements in electric lighting, proceeding largely from Germany, the exaggerated expectations which are now connected with it are to be deprecated.

Electric light up to the present suffers from the great disadvantage that a single machine can only with safety supply a single lamp. Such a lamp gives then, according to the size of the machine, a light of 1,000, 4,000, or 15,000 candles, with the expenditure of one, two, or six horse-power respectively. For lighting evenly large spaces, and for most lighting purposes, which gas-lighting has to fulfil, the concentration of the light is, however, very disadvantageous. It is possible that advancing art will in time overcome this weak point of electric lighting ; this path has already been followed up with profit, but in the meantime a general application of electric in place of gas light is not to be expected. The consideration is also against it, that the electric lamps cannot be placed at a great distance from the light machine unless very thick and therefore costly copper conducting wires are used.

I may be allowed, finally, to add a few remarks on the already mentioned appeal to the German love of justice in favour of foreign inventors. The Germans possess and exercise this love of justice as regards foreign performances in a prominent degree.

This not only holds good as regards German science, when it is always considered a point of honour, in the description of certain undertakings, conscientiously to give the labours of others in the same direction, but also as regards the German public, which is even always inclined to prefer what is foreign, "come from abroad,"

to home products. This leads very frequently to a manifest injustice to the latter, and forms a great obstacle to the successful progress of home industry. Whilst England, France, America always regards with pride the productions of its own industry and is always ready to give the preference to their productions, it is the contrary with us.

German industry is frequently compelled, through this prejudice of the German public for foreign productions, to bring their best products before the market as foreign, in order to obtain corresponding prices and sale, and only to issue indifferent cheap ware as their own manufacture. That injures the respect for our industry considerably, and stops their growth and progress. May the pride with which a German can now fortunately regard his united powerful fatherland soon lead him to be at least as just as regards home as foreign productions.

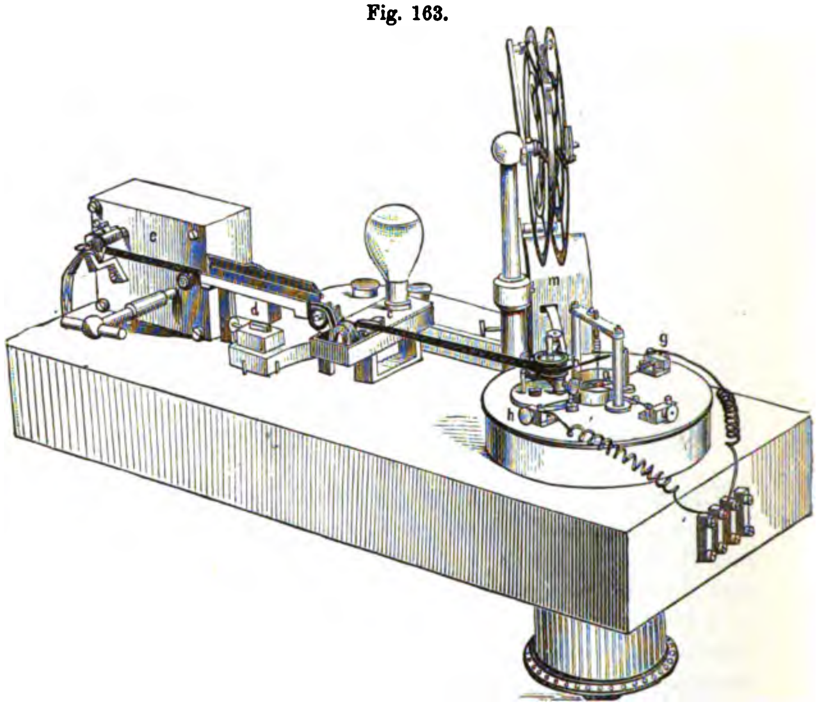
SIEMENS AND HALSKE'S SOOT WRITER.*

This writing apparatus, represented in Fig. 163, works, like Morse's original writing telegraph, Froment's writing apparatus, and Thomson's syphon recorder in such a way that the writing style describes on a paper strip a continuous straight line, when no current passes through the line, but that this line experiences a deflection to the one or other side, if and so long as a positive or negative current traverses the line. Differing from the above mentioned and other known telegraph apparatus the writing line is produced by the soot writer in such a way that a continuous blackened paper strip is led past the writing point, which presses lightly on it, whereby the soot clinging loosely to the paper is removed from the path described by the style, and this shows itself as a fine and distinctly white line. The continuous blackening of the paper band is effected by the paper being led forward under a roller of metal kept cold, to which it closely adheres, or another material which is a good conductor of heat,

* (English Patent, No. 1871, of 14th May, 1877.) 1877.

beneath which the smoky flame burns, and is thus kept cold itself. In this way the burning or charring of the paper is prevented. In order to fix the soot on the paper, and to make the writing thereby permanent, the smoked strip of paper, after it has taken up the writing, is led through under a hollowed roller, the

Fig. 163.



under portion of which dips into a vessel *c*, filled with alcohol, ether, or other liquid. If rosin or some such binding material is dissolved in this liquid it completely fixes the soot after drying. In order to accelerate this, we allow the paper strip before it reaches the rollers of the clockwork, which drives it forward continuously, to pass forward as a rule over a multiple wire netting, beneath which a small flame burns.*

* The method here described, of blackening and fixing the soot, has been worked out by Dr. O. Frölich, head of Siemens & Halske's Laboratory.

The motion of the writing point is brought about either by a polarized relay, with the moving tongue of which the writing point is connected, or by a light coil of wire, which we usually prepare from aluminium wire covered with silk, and which is suspended in a powerful ring-shaped magnetic field. In the first case the magnetic relay tongue, movable between the poles of the electro-magnet, is held back, or it may be brought back into the position of rest between the magnet poles by means of a spring the force of which increases more quickly when it is moved from the position of rest than the magnetic attraction between the poles and the tongue. This spring force is brought about most simply by keeping the tongue fixed in its place of rest by means of a stretched thread of steel wire or other elastic material, to the middle of which it is fixed. By altering the length and tension of the thread the ratio of the restoring force to the deflection from the place of rest can be regulated at will.

For long submarine or underground lines, in which a greater sensitiveness is requisite than can be obtained by electro-magnets in order to obtain sufficient velocity, we use the coil of aluminium wire supended from the spiral spring for the motion of the writing style. In order to bring back the same with sufficient rapidity into the position of rest, and to keep it at the same time swinging freely in the ring-shaped magnetic field without side fluctuations, two horizontally stretched elastic wire threads pass through the point of suspension of the coil to the spring, which serve at the same time as conducting wires for the aluminium wire of the coil. This arrangement has the advantage over that used by Bain and later by Thomson in his syphon recorder, in which the spiral of wire turns around an axis lying in the plane of its middle winding of much greater sensitiveness, because in it each portion of the coil moves with similar velocity, and therefore causes equal momentum, and because, farther, the coil completely fills the magnetic field, and because, finally, the latter is much more powerful than that of Bain's arrangement, in which the magnet poles stand much further from one another, and enclose a double intermediate space with enclosed iron core.

What we consider as new and our invention is :—

1. The use of blackened paper strips for the receipt of telegraphic messages, as well as the above-described manner of

blackening and the fixing of the soot after receipt of the message.

2. The motion of the writing style by a coil of wire swinging in a powerful ring-shaped magnetic field, or by the tongue of a polarized relay, which are kept in the position of rest, or are respectively brought back into it by the action of a spring.

3. The use of a stretched elastic thread, in the middle of which the relay tongue is fixed for producing this spring power.

THE SELENIUM PHOTOMETER.*

1877.

GENTLEMEN,—Whoever has been engaged in photometric researches knows how varying the results of such experiments are, so that the same observer with the same apparatus not only obtains varying results, but that another observer who repeats the observations arrives at totally different results. An instrument, therefore, which can introduce more certainty into photometric determinations must be hailed with satisfaction by all experts. As the arrangement of the selenium photometer is altogether new, you will allow me, before describing the instrument, to refer to its history. Superintendent May, of the Valencia cable station, discovered the wonderful property of the sensitiveness to light of selenium, which had been employed as a standard of resistance on account of its great conductive resistance. Lieutenant Sale, Professor Adams, and Dr. Werner Siemens have gone more closely into the matter.

Selenium, a simple semi-metal (metalloid) discovered in 1817 by Berzelius, is a body similar to glass, and, when melted and quickly cooled in thin layers allows light to pass through with a red colour. It is in this condition a perfect insulator of the electric current. If this amorphous selenium is heated above 100° C., it softens, gives up much latent heat, becomes perfectly crystalline even in the thinnest layers, and now conducts electricity to a very

* (Communication of Mr. C. Frischen at the Seventeenth Annual Meeting of the Society of Gas and Water Engineers of Germany, in June, 1877.)

slight extent. It thus attains the property of conducting electricity like liquids, that is the conductivity increases with the temperature, and therefore it behaves like carbon and tellurium. In this condition selenium is sensitive to light, for its conductivity increases with illumination, although only to a small extent. This action takes place with any coloured light, but the action of coloured light of the prismatic colours increases uninterruptedly from violet to red. The invisible chemically acting rays and the dark heat rays lying at the other end of the spectrum give no direct light action. In this respect selenium behaves, therefore, similarly to the retina of the eye.

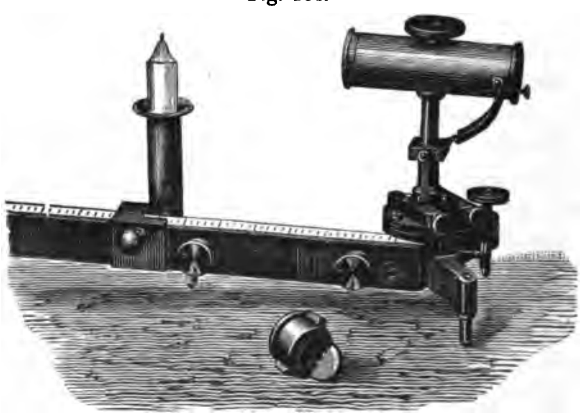
Dr. W. Siemens succeeded, by heating amorphous selenium for several hours at a temperature of 210° C., in producing a new modification of selenium, which possesses the property of a metallic conductor, the resistance of which diminishes with increasing heat. This modification of selenium has much greater conductivity, and correspondingly greater sensitiveness to light, and the latter is also constant in a high measure. Dr. Siemens also succeeded in preparing from this selenium easily sensitive preparations, which show with certainty even the slightest difference of light, and he further found that the increase of conductivity of these selenium preparations varied nearly as the square root of the strength of the light.

Dr. Siemens now aimed at basing a photometer on this, which should give the strength of light directly, and which does not compare lights with one another, as all known photometers do. But this attempt failed, for the sensitiveness to light of selenium is too little constant for this. On the other hand, the selenium served as an excellent means of verifying the equality of two light-effects, or of causing it, and thus of making the comparison of light independent of the eye of the observer. Such a selenium photometer is now before the meeting (Fig. 164). The selenium plate sensitive to light is fixed at the bottom of an open tube, which can be turned to the sources of light to be compared. An electric current is transmitted from a small galvanic battery through the selenium and through a sensitive galvanometer, which deflects the needle.

When the tube is opened and directed to a light the deflection of the galvanometer is increased. When the tube is

closed the deflection returns slowly to the old point. The tube is now turned to the source of light to be measured and kept there until the deflection attains a maximum, and is then directed again to the standard candle, which is pushed along the scale of distances until the previous deflection of the needle is reproduced. If now the action of the sources of light is alternated a few times, and the distance of the standard candle so arranged that no continuous difference of the deflection of the needle occurs any longer with either illumination, the intensities of the lights stand in the

Fig. 164.



inverse proportion to the square of the distances from the selenium plate.

The exactness of this method of measurement can be increased to any desired degree by increasing the selenium preparation and increasing the sensitiveness of the galvanometer, and is altogether independent of the varying capacities of the eye to recognize differences of light which interferes in all known photometers.

The selenium photometer is independent to a great extent of the colour of light. Differently coloured lights can hardly be compared with the usual photometer, and different observers will give as many different results. But the selenium photometer gives in this connection always a definite comparative value.

There is always another question, whether this value exactly corresponds to what practical photometry ought to give; we use

light to distinguish objects in form and colour, and an exact standard photometer should give this light value, not the greater or less sense of brightness.

Selenium is, however, more strongly affected by red light than, for instance, by blue. But whether we can distinguish better or worse with blue or red light, when such, for instance, exert an equal influence on the selenium photometer, is yet undecided, and must be first determined by experiments. These have already commenced, and it has already been found that in comparisons of the white electric light with the yellow candle light, the selenium photometer gives the luminosity of electric light as much less than other photometric methods.

Therefore, it is possible that with the comparison of different coloured light by means of the selenium photometer, its value is to be multiplied by a coefficient, which has to be determined for the different colours of the spectrum.

Anyhow, however, the selenium photometer gives definite data for the comparison of different coloured light, and this forms the most important advantage of the selenium photometer above all others.

The instrument can, therefore, be rightly recommended to the attention of lighting engineers.

ON TELEPHONY.*

The surprising performances of the electric telephones of Bell and Edison rightly claim in a high degree the interest of natural philosophers. The solution of the problem of conveying sounds and speech to distant places by its means promises to give mankind a new means of intercourse and culture, which will considerably influence their social relations, and will also be of essential service to science. It therefore appears fit for the Academy also to draw into the circle of its consideration these inventions of so much promise.

The possibility of mechanically reproducing not only sounds,

* Read in the Berlin Academy of Sciences, 21st January, 1878.

but also tunes and speech at great distances, is theoretically assured by Helmholtz's pioneer experiments, which laid clear the nature of timbre and inflection.

If, as he has shown, noises and sounds can only be distinguished from pure tones, in that the latter consist of simple, the former of multiple superposed wave series of the medium, rendering the sound possible, and if the speech inflections are to be considered as irregular vibrations, with which vocal sounds begin or end, the possibility is gained of reproducing by mechanical means a certain sequence of such vibrations at a distance. Practical life has in this as frequently anticipated science. The so-called speaking telegraph, not hitherto sufficiently considered, consisting of two membranes, which were stretched by a strong thread or wire, at the same time as thin or fine as possible, fixed to their centres, effects a sufficiently clear conveyance of speech at a distance of some hundreds of metres. The thread can be supported for the purpose at as many places as desired by elastic threads of a few inches in length, and can form any desired angle by similar elastic fixing angles, without the apparatus losing its capability of transmitting even the quite toneless whisper with perfect clearness and accuracy, a performance which hitherto no electric telephone has succeeded in effecting.

Although this speech telegraph, or more correctly, this thread telephone, has no practical value, because its action is confined to short distances, and is interrupted by wind and rain, yet it is on this account very remarkable, as it shows that stretched membranes are fit to take up all vibrations of air with which they are struck in an almost perfect manner, and on the other hand to give out again all tones of voice and noise when they are set in similar vibrations by mechanical means.

Reiss, as is known, was the first who sought to effect the conveyance of sounds by an electric current in place of a stretched thread. He utilized the vibrations of a membrane exposed to the sound waves to bring about the closing of contacts of a galvanic battery. The current waves thus set up traverse at the other end of the conductor the windings of an electro-magnet which, provided with suitable sounding arrangements, reproduced very nearly the same notes by which the membrane struck by the sound waves was set in vibration.

This could only be effected in a very imperfect way, for the contact arrangements were only workable with wide vibrations of the membrane, and could only give these back again imperfectly.

Bell appears to have first had the happy thought of producing the currents serving to transfer the vibrations by the vibrating membrane itself, since he made it of soft iron and placed its centre opposite and very near to the end of a steel magnet, surrounded with insulated wires. By the vibrations of the membrane the attraction between the plate and magnet, and with it the magnetic potential of the wound end of the bar magnet was alternately increased and diminished; currents are thus set up in the surrounding wire and in the conductor, which owing to the smallness of the vibrations of the plate produced electrical sine vibrations corresponding to the vibrations of the mass of air, which were, therefore, in the position to produce in a similar apparatus arranged at the other end of the line membrane and air vibrations. It remains immaterial in this case that, as Du Bois Reymond has shown (Archive for Physiology, 1877, pp. 573 and 582), the phases and amplitude ratios of the partial tones in the receiving membrane are other than in the transmitting membrane.

Edison discovered an essentially different way, as it appears, simultaneously with Bell. He uses a galvanic battery which sends a permanent current through the line.

In the circuit at the transmission end a layer of powdered graphite is inserted, which is gently pressed between two metal plates insulated from one another. The upper plate is fixed to the vibrating membrane and presses the powdered graphite more or less together, corresponding to the vibrations of the air. In this way the resistance of the graphite powder is correspondingly altered, and thus there are again brought about sinusoidal alterations of the strength of the current traversing the conductor equivalent to the vibrations of the air. As receiving apparatus Edison used no membrane, but another quite peculiar arrangement. It depends on the experience, that the friction which exists between a piece of metal and a paper band, soaked with a conducting fluid and pressed against the piece of metal, is diminished when a current passes through the paper to this piece of metal. I have found this remarkable phenomenon confirmed for the case, when the current is so directed, that hydrogen is evolved from the

metal plate, or when the piece of metal consists of a non-oxidizable metal. The reduction of the friction coefficient by the current, therefore, evidently proceeds from electrolytically produced gases, which are evolved at the metal plate.

But in this case the almost, so to speak, momentary speed with which the action takes place even with very weak currents remains wonderful.

Edison fixed the metal plate pressed against the damp paper on a sounding board, and drew the damp paper led over a roller by continuous revolution of this roller under the piece of metal. If the piece of metal and the metallic roller are inserted in the circuit, the current alterations which are brought about by the more or less compressed graphite powder effect equivalent alterations of the coefficient of friction between the piece of metal fixed to the sounding board and the paper, whereby each is thrown into corresponding vibration, which communicate themselves to the sounding board and through this to the air.

The Edison telephone is very remarkable for the novelty of the means employed in it, but is evidently not yet worked out for practical usefulness. The Bell telephone, on the other hand, has in its remarkably simple form found a great extension, especially in Germany, and there is already a considerable mass of experience to judge of its usefulness. It chiefly fails in the great weakness of the reproduced sounds which for clear understanding necessitates pressing the sounding opening close to the ear, and on the other hand that the same shall be directly spoken into. For this purpose a quiet surrounding is necessary, so that the ear shall not be blunted and disturbed by outside noises. A yet more important obstacle to its practical application is, however, the necessity for perfect electric rest. As extremely weak currents are brought about by the vibrating iron membrane of the other instrument in similar vibration, very weak foreign currents are sufficient to disturb the latter, and impart to the ear complicating noises from other sources.

In order to supply myself with a starting point for estimating the strength of the currents which are active in the telephone, I set up a Bell's telephone, the magnet poles of which were wound with 800 windings of 0·10 mm. thick copper wire of 110 mercury units resistance, in a circuit, which included a Daniell cell with a

commutator, by which the direction of the current was reversed 200 times a second.

Without an inserted resistance these current impulses produced in the telephone a noise audible at some distance, highly inharmonious, and hardly to be borne close to the ear. By the insertion of resistance the noise diminishes, but even with the insertion of 200,000 units was still very clearly audible. Even simple openings and closings of the battery were still clearly audible as a slight sound through the resistance. If six Daniells were joined up the noise could still be clearly heard through 10 million units. If 12 Daniells and 20 million units were inserted, the noise was decidedly clearer than in the previous case. In the same way, there was an increase in its strength, if 30 and 50 million units were inserted with 18 and 30 Daniells respectively. This is a confirmation of the observation of Beetz, that electro-magnetism is called forth with similar strength of curreut more quickly in circuits of great resistance with correspondingly greater electro-motive force than in circuits with less resistance and correspondingly less electromotive force, for the opposing currents arising in the windings are of greater importance in the latter than in the former case.

If the primary coils of a small Volta inductor, such as are generally used by physicians, are inserted in the circuit of the commutator, whilst telephone and resistance box are placed in the circuit of the secondary wire, a loud sounding noise is still heard with one Daniell with the insertion of 50 million mercury units, which continued clearly audible when the secondary spirals were placed quite at the end of the primary.

This great sensitiveness of the Bell telephone for weak currents makes it very applicable as a galvanoscope, especially for indicating weak, quickly altering currents, for which formerly there was hardly any other means of test than the convulsions of a frog's legs.

The telephone can also often be used with advantage instead of the galvanometer for the measurements of resistance, by means of the bridge method in the branch wire of the bridge. But in this case it is necessary to employ as resistances only straight wires extended at a great distance from each other, as otherwise disturbances would arise through induction.

The great sensitiveness of the telephone to electric disturbances

in lines is thus fully explained, which consequently almost entirely prevents its use on overhead wires employed for telegraph correspondence. Even if two neighbouring conductors on the same pole are employed to form the circuit, whereby the electrodynamic as well as electrostatic induction arising from the other distant wires is almost compensated, one still hears in the telephone every current passing through one of these wires as a loud, cracking noise, which when frequently repeated makes the telephonic message quite incomprehensible.

The disturbances are even worse when the earth is used to complete the circuit.

Even when special earth plates are used for the telephone wire, or gas or water-pipes are used for the purpose, every current is clearly heard, which is led through neighbouring earth plates to the earth. As the electric potential with the propagation of a current in the earth diminishes as the cube of the distance from the leading in point, this also demonstrates the exceeding sensitiveness of the telephone for weak currents.

With overhead wires telephones can only be used on this account when special posts are used for the telephone lines.

Further, the earth connection can only be used in places which have no telegraph stations, or where the earth plates used for telegraphing are far removed from those which are used for the telephone lines.

Notwithstanding this great sensitiveness of the Bell telephone, it still transmits the sound waves by which its membrane is hit only very incompletely to the corresponding membrane, and to the ear approached to it. When a loud ticking watch was approached to the sound opening of a very sensitive telephone constructed according to Bell's design, its loud tick could not be heard in the other telephone, even when the watch was quite close to the telephone casing. The above-mentioned thread telephone, on the contrary, transmitted the tick very clearly through a thread about 20 metres long. It was still audible when the watch was removed 8 cm. from the mouth of the cylindrical hearing tube. The tick was directly audible with almost equal clearness through a distance of 130 cm.; the thread telephone consequently transmitted about $\frac{1}{260}$ of the strength of the sound. As the electric telephone transmitted the slightest speech quite perfectly, it cannot transmit

the toneless ticking noise, although it is louder on account of the quick and irregular vibrations which they cause.

From the same cause, the real quite toneless whisper was no longer audible through the electric telephone, whilst still quite audible through the thread telephone at a distance of 20 metres. In the same way electric telephones, which transmit the slightest speech quite clearly, cannot transmit at all, or hardly perceptibly, the loud but toneless noise of two pieces of iron or glass.

It is remarkable that the electric telephone, notwithstanding this slight capacity to transmit noises arising from very quick and irregular vibrations, can give back so quickly the timbre of the tone and speech, that the voice of the speaker can be recognised as well through the telephone as directly. The voice sounds, however, somewhat more ringingly, which is to be ascribed to the circumstances, that the tones are better and more powerfully reproduced than the noise of speech. Singing also is given in the telephone as a rule softer and richer in tone than directly.

In order to obtain data as to what fraction of the strength of sound which hits the membrane of one telephone is given back by the other, I made some experiments with musical boxes. The smaller, which gave short sharp tones, was audible in the open air on an unobstructed plane by good ears at a distance of 125 metres, whilst with the telephone only individual notes were clearly heard when the telephone was removed further from the musical box than 0·2 metre. In this case only about $\frac{1}{390,000}$ part of the sound was actually transmitted. A somewhat larger musical box, which was pitched somewhat lower, and gave notes of longer duration, could not be heard in the open much further than the small musical box, but the telephone allowed the tune that was played to be recognized at a distance of 1·2 metre. This gives a transmission of about $\frac{1}{10000}$ of the strength of sound taken up by the telephone. If therefore speech, as well as deeper and more drawn-out notes, are apparently transmitted better than the tunes of musical boxes, it is not to be assumed that a Bell-telephone on the average transmits to the other telephone more than $\frac{1}{10000}$ of the mass of sound by which it is struck.

It follows from the above, that the Bell-telephone, notwithstanding its surprising performances, only effects the transmission of sound in a very imperfect way.

That we understand the speech of the telephone energised by such unusually weak currents, is due to the extraordinary sensitiveness and the wide range of our organs of hearing which make it possible to still hear at a distance of 50 kilometers, the same report of a cannon shot which they can tolerate at a distance of 5 meters, and therefore to perceive air vibrations as sound within the 100 millionth of their strength.

The telephone therefore needs, and is capable of, improvement in the highest degree. Even if it is not possible altogether to obviate the loss of sound, which would approximately be the case if it could be brought about, that the vibrations of the second membrane had the same amplitude as those of the first—as by the repeated transformations of motions and forces a loss of energy must always take place through change into heat, yet the existing disproportion is still much too great. With the reduction of this loss, and the strengthening of the arriving sound thereby produced, the ear would have to be less strained and could yet plainly perceive and distinguish the transmitted sounds at a greater distance from the instrument. The disturbances brought about through foreign slight electric currents would be covered by the voice arriving stronger.

The direction is hence also given which is to be taken for the improvement of the Bell-telephone.

In order to produce stronger currents the membrane for the reception of the wave-vibrations must be very large and so constituted that the sound waves striking its surface can transmit the greatest possible portion of their energy to it.

The membrane must hence be very moveable, in order that its vibrations may not be too small, and the work expended for bringing about electric currents must be so great that the *vis viva* collected in the vibrating membrane is consumed by it, or in other words so great that it makes the membrane vibrations aperiodic. An enlargement of the Bell iron diaphragm is only advantageous within very narrow limits, for larger and correspondingly thicker plates easily take up special vibrations, which reduce the clearness of the sounds transmitted. Also the magnetic attraction of the iron plate must not be raised too high in the Bell-telephone, as it is already too much bent and stretched on one side, which equally prejudices its clearness.

I have now sought with decided success to strengthen the magnetic attraction between the iron membrane and the magnet pole wound round with wire, without bringing the former out of its position of equilibrium by bringing it within the poles of a powerful horse-shoe magnet.

The pole above the iron plate forms a ring, the opening of which forms the tolerably large sound hole, whilst the lower pole of the horse-shoe opposite to the middle of the sound opening carries the iron pin provided with the coil of wire. The membrane itself was only formed of iron in the centre, so far as it was opposite to the ring-shaped pole, whilst the remainder was formed of sheet brass, to which the iron was soldered. Through the action of the magnetic iron ring the middle of the iron plate was now powerfully magnetized ; a very powerful attraction, therefore, took place between it and the opposite magnetic iron pin, whilst the iron plate, attracted equally powerfully on both sides, continued in a state of equilibrium with the whole membrane, and could therefore swing freely towards both sides.

Another modification consisted in that I made both magnetic poles ring-shaped, and fitted them with short slit iron tubes, provided with windings. Two similar ring-shaped magnet poles stood directly opposite to the iron plate, whilst this itself had the opposite polarity. This is the same combination which I frequently use in the so-called polarized relay with good result, in which the moveable, strongly magnetic iron tongue is between two oppositely magnetized magnet poles, removed equally far from it, the limbs of which are provided with windings.

This arrangement has also served for telephonic call apparatus. If one point of the rim of a steel bell, which is itself fixed to one pole of a horse-shoe magnet, is between two iron pins provided with windings, which form the other pole of the horse-shoe magnet, a second bell similarly disposed and arranged communicates each bell stroke to the other with surprising strength when the windings of both are arranged in a circuit. The same occurs with similarly pitched tuning forks.

Instead of two similarly disposed bells or tuning forks it is sufficient, when it is only a question of the transmission of the bell sound as an alarm signal, to place only one bell or tuning fork

in the telephone circuit. The telephones then give out loud sounding bell strokes.

Although in this way also the efficiency of the telephone can be considerably increased, still by retaining the Bell iron membrane one is kept within tolerably narrow limits, as well on account of the size of the membrane receiving the sound as of the strength of the actual magnetism, the overstepping of which makes speech indistinct, and gives it a foreign, unpleasant overtone.

For the construction of telephones supplying much more powerful currents, I therefore use no vibrating iron plate, but fix to the membrane receiving the sound waves, which is formed of non-magnetic material, a light coil of wire, which swings freely in a ring-shaped magnetic field. By the vibrations of the coil of wire there are induced in it powerful currents of alternate direction, which at the other end of the conductor set in similar vibrations either the coil of wire of a similar instrument or the iron membrane of a Bell-telephone.

As a flat membrane cannot be increased beyond a somewhat narrow limit without complicating the sounds transmitted, I have, by the advice of Helmholtz, given the membrane the form of the drum of the ear.

According to Helmholtz, one obtains this form if one stretches a damp skin of parchment or bladder over the rim of a ring, and then gradually presses down its centre by means of a screw or otherwise to the desired depth. In the dry state the membrane then retains this form. If now a metal model is formed from this membrane, metallic membranes can be made by its means out of brass, or better still aluminium plate, which have exactly the same shape as the first. Membranes so formed are specially suitable for taking up sound waves, and for the transmission of *vis viva* to masses to be set in vibration--a purpose which they have also to carry out in the ears—as their curvature occurs principally in the neighbourhood of the edge of the membrane, whilst in flat membranes this takes place rather close to the centre, in them therefore only the sound waves striking the centre of the plate have full action. Such a telephone with a parchment membrane of 20cm. diameter, a coil of wire of 25mm. diameter, 10mm. height, and 5mm. thickness, arranged in a powerful magnetic field produced by a strong electro-magnet, transmits every sound produced

in a room of large size from every part with perfect clearness to a large number of smaller telephones. What is remarkable therein is the great purity and clearness with which the telephone transmits speech and notes. This is partly due to the appropriate shape of the membrane, and partly to the fact that the coil in its displacements in the cylindrical magnetic field produces more regular sinuoidal currents than a vibrating iron plate. If such a coil of wire is moved quickly up and down by means of a handle with a long connecting rod, such an apparatus can be made use of with advantage for the production of powerful sine currents.

For the reproduction of speech the drum-shaped membrane is less serviceable. It appears also, in general, more judicious to transmit with powerful large instruments and to receive with smaller, more delicate and lightly constructed ones, whereby the instrument is brought to the ear in the best position.

Too powerful receiving instruments have the disadvantage that the opposing currents produced by the vibrations of their membranes weaken the moving currents, whereby speech becomes indistinct and takes up foreign sounds.

It is in general hardly to be assumed that telephones will be successfully constructed according to Bell's principle, according to which the sound waves themselves have to accomplish the work of inducing the currents necessary for their transmission in such a way that they speak a speech clearly audible at great distance from the telephone, and it is quite impossible, as already noticed, to obtain from them a reproduction of the mass of sound, by which its membrane is struck, which is undiminished or even strengthened. This possibility is, however, not excluded when a galvanic battery is used for the movement of the membrane of the receiving apparatus, which then provides the work to be used. Reis has sought to effect this by the aid of contacts, Edison with the help of graphite powder, which he inserted in the circuit of the battery.

Contacts will hardly act with sufficient constancy and certainty to give back the speech clearly. But it is possible that the problem will be solved by the means taken by Edison. All that is required is to find out a material or arrangement by means of which considerable alterations of the resistance of the circuit are brought about proportional to the amplitude of vibration of the

membrane. Graphite powder has too changeable a form and nature to be able to perform this task with certainty. Experiments with other contrivances which I have tried have so far given no satisfactory result. Notwithstanding this Edison's precedence continues very worthy of notice, for it probably forms the key to future important developments of telephony.

But although telephonic instruments may be susceptible of further improvement within wide limits, the conductors will always limit the range of application somewhat narrowly. And even if, as has already been shown to be necessary, special poles are employed for telephonic lines on which there are no telegraph wires, and double lines are everywhere used for the telephone, telephonic correspondence over numerous conductors fixed on the same poles would be disturbed mutually with the increasing length of the lines, by branch currents passing on to the neighbouring circuits owing to imperfect insulation, by electrodynamic and electrostatic induction producing secondary currents in them, which again produce complicated noises. Electrodynamic induction may, as a rule, be neglected with telegraphic lines, as it does not increase with the length of the lines if the resistance of the coils of wires is left out of account, and the duration of the induced electrodynamic currents is too short to be able to influence telegraphic instruments. With telephonic apparatus the short currents produced by Volta induction produce, however, very perceptible sounds, when the lines run near each other even on short tracts.

Secondary electrostatic induction, which increases with the square of the length of the line, will further place a limit to the applicability of telephones, in the case of overhead conductors, even when telephonic conductors alone are fixed to the same poles.

Circumstances are much more favourable in this connection when underground or submarine lines are used. Before I had recognized that the strength of the currents is so extraordinarily small which are able to excite the telephone to produce clearly understood speech I doubted the applicability of underground lines to great distances on account of the great weakening which the current waves called forth through quickly increasing electromotive forces in the conductors sustain with the length of the line.

The experiments which the Postmaster-General, Dr. Stephan

(to whom the German Empire is indebted for the re-introduction of underground conductors, which have almost been forgotten for the last quarter of a century) has instituted with the Bell-telephone, gave the surprising result that one can speak with it at distances of about 60 kilometres quite clearly and comprehensibly. It is, therefore, very probable that with telephones of increased action messages will be well understood at double or even treble that distance. This may at present be regarded as the limit within which telephonic correspondence is practically applicable.

Unfortunately even with underground conductors disturbances through return currents in the earth as well as through electro-dynamic and electrostatic induction are not excluded. The former may be almost completely got over, as in the case of overhead lines, by the use of complete metallic circuits, with the earth cut out as return circuit. The same is of good effect in the case also of disturbances through induction, when both insulated conductors forming a telephone circuit are united in a special cable wrapped round with iron wires. When, on the contrary, as is usually the case to save cost, a great number of insulated conductors are united in one cable, Volta and static induction, on account of the small distance, occurs in increased measure, and acts very disturbingly on the telephone correspondence. This secondary electrostatic induction occurs also with long cable lines for telegraphic correspondence in which very delicate apparatus has to be used.

I have, therefore, proposed for their removal to provide the single conductors made up into a multiple cored cable with a conducting metallic sheath, which is in conductive connection with the earth, or with the iron armouring; even a wrapping round of the single insulated conductors with a thin layer of tinfoil removes the secondary electrostatic induction. One can easily be convinced of this by the experiment of laying two pieces of mica or gutta-percha, covered on both sides with tinfoil, upon one another. If the inner coatings are insulated and the charge between the outer coating is tested by the deflection of a galvanometer, by connecting the one pole of a battery the other pole of which is earthed with the one outer coating, and connecting the second through the galvanometer wire with the earth, or in a similar way with the help of a commutator, as great a charge is obtained as if the

middle coatings were wanting. If the latter are, however, connected with the earth, there is not the slightest sign of a secondary charge obtained in the tinfoil covering connected with the galvanometer.

The same negative result is obtained if a cable consisting of several conductors is surrounded through its whole length with tinfoil or thin strips of any other metal. The metallic conducting surface, however thin, completely prevents any secondary electrostatic induction or charge of one conductor through the charge of another. On the other hand, the electrodynamic induction of the wires on each other is not thereby arrested, as Foucault asserted.*

One can easily be convinced of this by means of a simple experiment. If two wires, insulated with guttapercha or indiarubber, are wound together on a bobbin, powerful charging as well as Volta induction currents are to be observed in one wire, if a galvanic battery is alternately opened and closed through the other. If the bobbin is now placed in a vessel which is filled by degrees with water, the charging currents diminish in the first wire and quite cease when the water has quite filled the intermediate space between the wires, by means of which the electrodynamic induced currents become somewhat larger.

These electrodynamic induced currents are not of importance for telegraph lines, as already noticed, because they do not increase with the length of the conductor; the exceedingly sensitive telephone is, nevertheless, excited by them when the inducing currents are not exceedingly weak. Special cables must, therefore, also be laid for telephones, as they also require special poles for overhead wires.

As follows from the above, the telephone is capable of great improvement. Telephones will certainly be set up in a short time which will transmit to considerable distances speech as well as musical notes decidedly louder, clearer, and purer than up till now is possible with the Bell-telephone.

The telephone will then be of great service for the business in

* Foucault took out a patent in England on the 2nd July, 1869, for the surrounding of single conductors with the foil or other conducting bodies, with the declared object of compensating the electrodynamic induction through the opposed currents arising in the tin covering.

towns and between neighbouring places, which far surpass what may be expected of the telegraphs for short distances. The telephone is an electric speaking tube, which like this can be used by anyone, and can completely supplant personal interviews. But as it cannot replace the speaking tube for very short distances, as little can it replace the telegraph for long ones. Yet in the limited circle of its applicability it will be numbered amongst the most powerful levers of modern culture, if external obstacles are not raised to its extension and application.

ON THE ELECTRIC RAILWAY OF THE BERLIN INDUSTRIAL EXHIBITION.*

GENTLEMEN,—If you wish it I am all the more ready to speak about the electric railway, as I have heard that its construction is frequently incorrectly understood. This railway is nothing else than an example of the transmission of power, as shown in another part of the exhibition, where a dynamo-electric machine drives another, which for its part sets a loom in action the great shuttles of which work very well. In this case a regulator is applied which works very accurately. The same principle of the transmission of power by dynamo-electric machines is now to be applied on the railway for the motion of carriages. The first inducement to the arrangement was due to a question of the architect Westphal of Cottbus as to the possibility of transmitting the energy of coal burnt there to Berlin. The person referred to had read a remark of my brother William in London on the possibility of transmitting the power of the Niagara Falls, and wished to carry it out in practice here. If this was not practicable, yet we have approached the matter more closely to see how far the electrical transmission of power can be used for transport by railways.

The experiment we made has turned out very well. The arrangement as you find it in the exhibition is the following: a

* (Address to the Society for the Extension of Industry, 9th June, 1879.)

small, narrow gauge railway is laid down, the rails of which form a closed curve. There is a third rail between the other two, a bar of iron on edge. The locomotive carries two rollers, by means of which it is in connection with the latter—whether rollers or brushes are better is yet to be proved. A dynamo-electric machine stands in the machine-room, and a similar one forms the locomotive. The machine in the machine-room is driven by means of a steam-engine. One of its terminals is in connection with the middle rail, whilst the other is connected with the outer rails. In consequence of this there is an electric difference between the middle and outer rails, and the dynamo-electric machine of the locomotive, which now acts as an electro-magnetic working machine, carries, by means of its surrounding wires, the electric current from the inner to the outer rail, the wheels of the locomotive making contact with the outer rails. Wherever, therefore, the machine is on the rails it is traversed by the current of the dynamo-electric machine in the machine-room, and therefore continues its progress until the current is stopped. We must here keep in mind that these are dynamo-electric machines which form their own magnets. I chose this name when I first communicated the principle of the dynamo-electric machine to the Berlin Academy of Sciences in the year 1867, in analogy with the usual designations "electro-magnetic" and "magneto-electric" machines, the former of which generate magnetism from the existing current, the latter current from existing magnetism, whereas in dynamo-electric machines mechanical energy is converted directly into currents. The small remanent magnetism, which always remains behind in the iron of electro-magnets, is sufficient in these machines to produce a very weak current in the moving part of the machine; this strengthens the magnetism of the fixed magnets, whereby again a stronger current is produced, and in this way the magnetism increases automatically through the energy expended until the currents become as strong as the wires carrying them can stand without becoming overheated. Now, if in such an active dynamo-electric circuit the conductor is anywhere broken, the electric current ceases, and at the same time the magnetism of the primary machine. To this circumstance it is due that faulty insulation of the rails is not very injurious. If the locomotive is running, its conducting wires form a much better conductor than the damp

earth, and if the conductor is broken this shunt current is not sufficient to maintain the dynamo-electric action at work, the magnetism, therefore, disappears, and concurrently the shunt current. The transmission of power, and also the velocity, can be increased within wide limits. The whole thing is, however, still too new for it to be possible to give absolute data as to what may be attained in practice.

We have obtained 30, 40, and 60 per cent. transmission of power, but can only give definite figures after longer practice. How far the loss of energy can be reduced with electric transmission cannot be estimated. Provisionally one must be satisfied with the production of 30 or 40 per cent. of effective work. The electric transmission of power has a great advantage in that it automatically solves a hitherto unsolved mechanical problem. This is the construction which results in machines being able to work with full power, as well when moving slowly as quickly. Had this problem been practically solved purely mechanically we should have been further advanced in the construction of street locomotives. With dynamo-electric transmission of power it is otherwise. If the power supplying or secondary machine has to do much work, and consequently runs slowly, the opposing currents produced by it are correspondingly weak, and in the same measure the current through the conductor increases. In this way the electro-magnetism and the tractive power of the machine dependent on it is increased. The dynamo-electric locomotive has further the advantage, that it also has in itself the power of acting as a brake, as it takes the part of a primary or current generating machine, when it turns more quickly than this latter, and consequently tends to turn this, and with it the driving steam-engine in the opposite direction.

I imagine soon many cases will occur where electric transmission, as well as electric locomotives, can be applied with advantage. The machine at the exhibitions was not originally made to move the three elegant carriages with eighteen to twenty-four persons in one to two minutes over the circular railway about thirty metres long, but to raise coal from the coal mines of Mr. Westphal. One must, therefore, consider with indulgence its performances, as an express locomotive for the public at the exhibition.

The question of what extension it is possible to give to the

application of the dynamo-electric machine is so far difficult to solve. It depends in the first place on the resistance of the rails, and secondly on the possibility of sufficiently insulating them. The first requisite, a smaller resistance of the rails, is partly obtained with longer lines, by setting up extra primary dynamo machines in different places, which maintain the electric difference of potential between the inner and outer rails. The second can hardly be arranged for long lines otherwise than by the construction of elevated railways. In the first ardour of invention after the discovery of the dynamo-electric principle, and the possibility thereby given, to produce sufficiently strong currents cheaply, I already dreamed of a net of elevated electric railway lines over the streets of Berlin, whose low-water level unfortunately admitted of no underground railway system, and gave expression to the same in a communication in this place. But a long line of technical advance, up to the present point, had first to be traversed, and a great deal more water will flow through the Spree, before my dream can be carried out, even to a small degree.

THE ELECTRIC LIGHTING OF THE IMPERIAL GALLERY.*

THE telegraph works of Siemens & Halske, of this place, whose rich exhibition of new and important inventions forms an ornament of the Berlin Industrial Exhibition, has been, as is known, the pioneer also in electric lighting methods. Already long ago electric light has been produced from galvanic batteries, and the Alliance Company in Paris early succeeded in producing electric light by machines and in supplying lighthouses with the same light produced from mechanical energy, yet these methods for the advancement of the electric light were, on account of their costliness, unsuited to give the electric light greater consequence and extensive application. A great advance in the progress of electric lighting was made in the year 1866 by the Englishman

* "National Zeitung," June, 1879.

Wilde. He made use of the magneto-electric machine improved by Siemens & Halske, by the introduction of the "cylinder" magnet (Siemens' armature), to magnetize large electro-magnets, which in a second machine constructed in the same way took the place of steel magnets. As electro-magnets are much stronger than steel magnets, and do not lose their magnetism as the latter do, he succeeded by means of this combination in producing electric currents of a strength hitherto unknown.

But the unreliable steel magnets always remained as the real generator of the electric current, and a safe basis for its mechanical production was thus still wanting. This was given by the discovery by Dr. Werner Siemeus of the principle of the dynamo-electric machine. This principle, first published at the meeting of the Berlin Academy of Sciences of the 17th January, 1867, consists in the simultaneous strengthening of the magnetizing current and that produced by the electro-magnets in the same machine through the energy employed. The last remnant of magnetism remaining in the electro-magnet was sufficient in such dynamo-electric machines to produce, after a few revolutions of the machine, as powerful currents in the surrounding wires of the electro-magnets as these could take up without getting heated. In this way it became possible to transform energy directly, without the interposition of weak and unreliable steel magnets, into electric current, and *vice versâ* electric current into work. Quite a new line was thus opened to technical art the full importance of which will be recognized in course of time. The applications of the dynamo-electric machine to the transmission of power tc copper refining, &c., as they may be seen in the Berlin Industrial Exhibition, will be spoken of on other occasions. Here only the further extension of electric lighting methods will be referred to, the "last word" of which lies before us in the lighting of the Imperial Gallery by Siemens & Halske, which is to-day opened as an annexe to the Berlin Industrial Exhibition. Siemens & Halske's machine, and that of Wilde, founded on it with the Siemens armature, have the disadvantage that the electro-magnets are highly heated through the quick alteration of the magnetism, and that the currents produced of rapidly alternating direction must be first changed by means of a commutator into direct or similarly directed currents.

The problem of producing direct currents by a direct method by means of dynamo-electric or electro-dynamic machines has, it appears, been solved on many sides, quite independently. This was first arrived at in a current-producing machine used for telegraphic purposes, which was exhibited by Siemens & Halske in the Paris Exhibition of 1855, and later in the Historical Exhibition in Vienna, and at present in the Post Museum of this town. In the same way Professor Pacinotti, of Florence, in the year 1863, constructed a similar magneto-electric machine which directly produced similar directed currents. Somewhat later Gramme built in Paris such a Pacinotti machine of large size, in which later, after becoming aware of the dynamo-electric principle, he replaced the steel by electro-magnets, and thus produced a machine suitable for practical lighting work. The solution of the problem was worked out by von Hefner Alteneck in a more perfect manner, which differs essentially from those of Pacinotti and Gramme in that the current producing part of the machine is not an iron ring wound round but a transverse iron cylinder wound round, by which means its effect is considerably increased.

By means of these dynamo-electric machines of Pacinotti-Gramme, and von Hefner's construction, the problem of the production of current by means of power was solved in a very perfect manner, and lighting arrangements based hereon are already very much extended. The difficulties which are opposed to the introduction of electric lighting to a larger extent lie in the fact that each machine could only produce one light, though of great power. A division of the electric light into several smaller ones was not practicable with the regulators or lamps hitherto known, or only in a very uncertain manner. Mr. Jablochkoff, of Russia, made the first actual advance in this direction by means of the electric candle, invented by him. Of these candles, which consist of two parallel pieces of thin carbon, placed close together, with a separating piece of gypsum, four or five can be inserted in the same circuit, when currents of alternating direction (alternate currents) are employed. At first only the magneto-electric machines of the Alliance Company, already described, could be used as generating machines, but the use of both Gramme and Siemens and Halske's alternating current machines, with electro-magnets in place of steel magnets and dynamo-electric current

production, was soon successfully made, by means of which electric lighting with Jablochkoff candles soon found an important application.

Siemens and Halske's alternate current machine, constructed on a new principle, patented in every country, by Mr. von Hefner Alteneck, the chief for many years of the construction department of the said firm, which is also used for the lighting of the passage, is superior to the Gramme by using less power and getting less heated, and competes with the French machine with success in all countries, and even in France.

But there are also essential deficiencies in the candles, which impede the general application of the electric light. In particular in their use there is the trouble that all the candles in the same circuit are extinguished if one goes out, or if the velocity of the primemover varies only slightly, and that then they cannot light again automatically. Besides, the light of these candles is not so steady as is necessary for lighting work and reading rooms.

The electric lighting of the Imperial Gallery opened to-day now supplies the public for the first time with a further extension of electric lighting methods. Siemens and Halske have recently arrived at the solution of the problem which has been attempted everywhere of the division of the electric light by the use of automatic regulators. This is essentially effected so that not only, as in electric lamps hitherto used, the strength of the current in the whole circuit regulates the distance of the carbons, but that by means of a shunt the resistance of each separate light is automatically corrected. This principle of the use of shunts to the lamps for regulation was already applied in previous constructions of the firm's lamps and patented in many countries, but recently M. von Hefner-Alteneck, by the use of a very sensitive differential action of the electric current, has constructed very simple and perfect acting lamps, which completely solve the problem. With the help of these differential lamps certainly theoretically as many lamps as desired can be brought into one circuit, but by its means an unlimited division of the electric light cannot be effected, as the electro-motive force of the machine must then possess an amount dangerous for its preservation. Too extensive a division has the disadvantage that the total amount of the light diminishes in a high degree with the division. One must therefore be satisfied

with setting, at the most, double as many lamps as Jablochkoff candles, in the circuit of an alternating machine. The differential lamps have this advantage over the candles that the extinguishing of a single lamp in the circuit cannot occur, unless the machine absolutely stops or there is a break in the circuit, and that the lamps automatically relight if they have been extinguished through such external causes. And besides, one can allow one or other lamp to be put out without affecting the other lamps in the circuit. Lamp lighting has besides the farther advantage over candle lighting, that the cost of the carbons is smaller than the candles, that the cost of electric lighting under circumstances is considerably less than gas lighting. To prevent misunderstanding, it must be further explained that it is only a question here of the division of the electric arc, which has hitherto not been done with safety. By means of the electric lighting recently effected with glowing pieces of coke, platinum wire, &c., by Reynier of Paris, Markus of Vienna, Edison of America, and others, certainly an extensive division of the electric light can be effected without danger, but such glow lights give relatively little light, and cannot be properly called electric lighting in the sense hitherto used.

ELECTRICITY IN THE SERVICE OF LIFE.*

GENTLEMEN,—It may appear strange that, at this meeting devoted to scientific endeavours, I undertake to speak upon a subject which, according to its title "Electricity in the service of life," appears rather to be of a technical than scientific character. Now, gentlemen, already some years ago I said in my inaugural address in another place, where, as the loved friend of my youth, du Bois Reymond, correcting me replied, "the progress of scientific knowledge is dependent on itself alone," that the high and true vocation of science is "to increase the store of knowledge and pcwer of the whole of mankind, and to bring it thereby to a higher

* Address in the Physical Section of the Meeting of Natural Philosophers at Baden-Baden, 1879.

level of culture." It therefore seems well for a scientific association, from time to time to look about in life, and enjoy the results which scientific investigation in connection with practical creative activity has achieved in this direction. At the same time I do not wish however to be misunderstood, as though I would measure the value of scientific investigation in general with the measure of practical advantage. Every new thought, every newly perceived fact, every better knowledge, is an increase of the one great valuable treasure of mankind, their store of knowledge, and to enrich this, without that consideration for present direct advantage or gain connected with it, has always been a special title of honour of German science, and will, it is to be hoped, long continue so. We can never tell beforehand whether a quite insignificant increase of our knowledge may not, sooner or later, be of great importance. Who, in his time, could have had a presentiment that Galvani's insignificant observation that the leg of a frog under certain conditions, moved when touched with an iron grating, would be the point of departure for the discovery of an important natural law, which, after a short time, would forcibly transform the life of mankind to an extent which is as yet immeasurable, and would increase their dominion over the powers of nature. Our fathers were partly contemporaries of Galvani and Volta, have therefore stood by the cradle of Galvanism, and at present there is hardly a great department of life in which the electric current does not exert a transforming or at least a helping and animating influence.

I will neither trouble you with the description of all applications of the electric current to practical purposes, nor bring before you a history of these applications; but a short reference to its many-sidedness, as well as to the limits striven for and attained in the different periods of development, would be in place, for what one has always for a long time been accustomed to, one easily considers as self-evident, and one hardly remembers the time when it was wanting. Who is now surprised that the telegraph brings him news in a few minutes or may be hours from far distant friends, that he finds daily in the newspapers an epitome of all the important events which have happened on the same or preceding day in all the lands of the earth? To whom does it now appear strange that the electric current precipitates metals in the solid state from their solutions? And yet the older ones among you will remember

their reverential astonishment at the mysterious control of natural forces, when they assisted for the first time in a telegraphic correspondence with a distant place, or when they observed for the first time how in the gilding cell, a common metal was covered in a few moments before their eyes, with a solid coating of dazzling gold. Our youth now looks upon telegraphy and electro-plating, like steam engines and railways, as so many things of course, as our older generation, which has seen the origin of these things, or actually taken part in their creation, in their young days perhaps, looked upon gunpowder and printing. One actually feels tempted to pity a young man that he has not been permitted to take part in this creative process of development, if one did not grudge him the prospect of creating the wonders of the future which must shoot up from the seed that we have sown.

Soon after Volta had discovered the basis of our present knowledge of the electric current, and had found means by the construction of the Voltaic battery named after him, of producing a permanent electric current, inventive minds began to ponder as to the usefulness of this new wonderful force. Already, in 1808, Dr. Sömmering proposed to employ it for telegraphy and produced a model which was in condition to carry out the purpose. To carry out his plan required certainly many long years of earnest skilled work. Only after Oersted had revealed the physiological, chemical and thermal actions of the current, and also its inductive properties, and its laws had been explored by such men as Ampère, Schweigger, Arago, Faraday, Gauss and Weber, Wheatstone, Lenz and Jacobi, Poggendorff, Dove, and many others, could Sömmering's bold plan be realized. But although the telegraphs which Gauss and Weber in Göttingen and Steinheil in Munich, actually produced in the beginning of the thirties worked well, another ten years passed, before the practical sense of the American and Englishman brought telegraphy actually into every day life. From this time forward, about 30 years ago, telegraphy begins its quick development up to its present high significance in the civilized life of mankind. All nations take part in this race, including our German Fatherland in the first line. What an indispensable means of intercourse telegraphy has already become, is best shewn when, through violent storms or some other extraordinary occurrence, a lasting disturbance of telegraph business takes place.

This is found to be a hardly endurable calamity and numberless interests suffer severely thereby. But nevertheless the process of development gives security for this, that we stand at the commencement of the telegraph era. For it is only in the most recent times that the telephone has been invented, which has given to the telegraph, which previously sent word, wrote, printed and drew, the power of directly transmitting human speech. But the telegraph in a wider sense is not restricted to the communication of news. The possibility due to the electric current of performing without remarkable loss of time, a mechanical action at a distant place, has imposed on it a great number of further services. The railway telegraph regulates the running of trains, electric signal arrangements of all kinds protect these and the public against danger. The block apparatus increase the efficiency of railway lines, the station block apparatus guide the trains safely through the confusion of tracks and points of stations, whilst they avert derailments or collisions which might arise through mistakes or negligence. The electric bell supplants more and more the inconvenient and uncertain mechanical one as well in dwelling houses as in factories and mines. The fire telegraph announces the commencement of a fire when it can be easily put out, and an attempted burglary is automatically announced by telegraph. The military telegraph guides the motion and maintenance of armies, the outpost telegraph brings its most distant feelers the outposts in permanent direct communication with the command. The electric distance measurer announces to the batteries the distance and position of the enemy's ship and indicates the moment when the destruction-bringing torpedo is to be electrically fired. The electric current measures the velocity of projectiles through the air, and the increase of its velocity at every portion of the bore of the gun. The exchange telegraph brings to bankers continually, and without any trouble, the rates of all the exchanges, and prints on their work table the important political events. To seamen and landsmen, the telegraph announces that a storm is slowly approaching. The electric water-level indicator shows at the pumping station at each moment the height of water in the reservoir, to the mariner in the harbour the depth of water above the bar that has to be crossed. The electric mine gas alarm warns of the danger of explosion during thunderstorms. Wherever one looks, the electric current

acts in short, as helper or protector. Yet it is not alone the great velocity of transmission of the electric current which makes it so serviceable for the quick conveyance of signals and especially for the performance of slight mechanical work at distant places and has procured it an extended use in life, but also its first discovered properties, its physiological, chemical and thermal actions. Physicians make use for the healing of the diseases of mankind, of the electric current, and make bloodless operations with wires electrically brought to red heat; the miner explodes his mine by means of galvanic batteries, or with the help of magneto-electric or dynamo-electric mine exploders. The electro-plater leaves to the electric current the filling of his moulds with solid metal; the electric current engraves, gilds, silvers, coppers, and nickels. It serves the chemist for carrying out his analyses, the physicist for his scientific experiments in numerous instruments and methods.

In all these applications of the electric current no great work is imposed, and for carrying them out, galvanic batteries perfected by degrees or magneto-inductors suffice. The idea soon occurred, to pass this limit, and also to produce greater results from the electric current. Such a problem was the production of the electric light. If a conductor traversed by the electric current is suddenly broken, an illuminating spark takes place at the point of fracture. If the current and the electric potential which produces it is strong enough, and the distance between the ends of the broken conductor is not too great, the current continues and the separating air space is filled with a glowing appearance of light, the so-called Davy arc, which reproduces the conductive continuity. The arc is specially brilliant and illuminating if the ends of the conductor are formed of carbon. This electric light has much occupied scientific and technical men and has found much application. But for its production, galvanic batteries with a great number of large cells were necessary, the making and maintenance of which are costly, the setting up of which is troublesome, and the strong exhalations from which are noxious. The application of the electric light therefore, remained very restricted for nearly half a century. The construction and application of large magneto-electric machines, to which I shall revert later, has altered this but little. It had just as little result in producing or transmitting considerable work by means of the electric current. There are a great number of

constructors of whom I will only here name Jacobi of St. Petersburg the inventor of electro-plating, and the American, Page, who have been occupied with the construction of large electric power machines; the late German Diet had even offered a national reward for a successful construction of such machines. All these efforts however, were thwarted by the costliness and difficulty of the production of the strong currents required. Page certainly succeeded in constructing an electric machine of several horse power, and Jacobi travelled with an electrically propelled boat on the Neva; yet finally the latter himself on the basis of his experiments declared the solution of the problem to be impossible, because the production of the electric current by means of galvanic batteries was too costly and because, further, through the opposing force generated by the working electric machine, the power of the battery was too much reduced. We must arrive at the same judgment through the Meyer-Helmholtz law of the conservation of energy. According to it, work is the equivalent of the heat which is expended in its production. In the steam engine, this heat is produced by the burning of coal, in the electric machine by the burning of zinc in nitric acid, or some other oxidizing liquid. This is, however, an incomparably more costly fuel than coal. We should therefore be obliged to give up the direct production of large forces by electricity at least until science has shewn quite new means, leading to cheap production of powerful electric currents.

But if for the first production of work, we are dependent on heat engines, which change heat into work either directly or by means of steam, or to the use of the sources of energy existing in nature, the question arises, whether we cannot apply these natural forces with advantage to the production of powerful electric currents, which again on their side can be used for the production of electric light, for galvanic changes, or for the transmission of power to other places. In fact this is practicable with the help of magneto-electric machines, and has, indeed, been done for a long time. The magneto-electric machine depends on the induction discovered by Faraday, *i.e.* on the fact that in a conductor joined up to form a conducting circuit, which is approached to another conductor in which a current circulates, there arises on the approach an oppositely directed current, and on the removal on

the other hand a similarly directed current. The same thing happens if a magnet is used instead of the conductor traversed by a continuous current, to which the conductor is approached or from which it is removed. As similarly directed currents attract and oppositely directed repel one another, both the approach of the induced conductor to the conductor continuously traversed by the current or to the magnet taking its place, as also its removal necessitate a consumption of work equivalent to the current produced. The machines for the production of electric current based on this were called magneto-electric machines in contrast to the electro-magnetic, in order to signify thereby, that with magneto-electric machines an electric current is produced with the help of existing permanent magnets, with electro-magnetic machines on the other hand work is produced by an existing current. Magneto-electric current generators are constructed in many different forms, and form one of the most important aids to electrical science. It has also been possible to construct magneto-electric machines of such strength, that by means of the current generated by them, electric light can be produced. But there is a difficulty in connection with them, which limits their applicability. Steel magnets take only a slight degree of magnetism, in comparison with electro-magnets, and they mutually weaken each other, when their similar poles are approached or many of them are joined into one large magnet. Magneto-electric machines must therefore be constructed of very large dimensions, if powerful currents are to be produced, which makes them very heavy and costly. Besides a large number of steel magnets contiguous to each other lose their magnetism with time, under the action of the unavoidable shocks which they sustain. Useful and indispensable as magneto-electric machines are for the production of slight currents, yet they do not serve for the production of such strong currents as are required for electric light, transmission of power, and employment for metallurgical purposes.

The English mechanician Wilde made a first remarkable step in this direction, in that he combined a small magneto-electric machine with a larger one, and in the latter replaced the steel magnet by a large electro-magnet. He made use for this purpose of my construction of magneto-electric machines in which the mobile part takes the form of a cylinder rotating on its axis.

(Double T armature.) If both cylinders are then caused to rotate, and the current of the magneto-electric machine, redressed by a commutator, is led through the windings of the fixed electro-magnet of the greater, the latter produces very powerful currents, which were used by Wilde for the production of electric light, and for the purpose of depositing copper on a large scale.

I succeeded in solving the problem of the safe and cheap production of powerful electric currents in another way in which the use of steel magnets was quite obviated. The principle upon which these machines rest is the same as that upon which are founded the electric machines of Töpler and Holtz, that of reinforcing the cause of the production of electric potential by the action of the same. If the steel magnets of a magneto-electric machine are supposed to be replaced by electro-magnets, and the currents of the rotating part of the machine, rectified by means of a commutator, are so directed through the windings of the electro-magnets replacing the steel magnets, that the current increases the magnetism in the right direction, the strengthened magnetism must produce still stronger currents and so forth, until, when the revolution continues uniformly, either the maximum of magnetism in the iron is reached, or the machine is destroyed by too great a production of heat in the wires. A very small quantity of magnetism in the fixed electro-magnets suffices to begin the automatic increasing action or for starting the machine. Not only the remanent magnetism in the softest iron suffices for the immediate starting of the machine, but this is brought about already in newly made machines by the earth's magnetism. I called these machines dynamo-electric machines in my first communication to the Berlin Academy of Sciences in January, 1867, on the principle lying at the foundation of them, in order to explain thereby that through them motive power was changed directly into electric current, that is in this case without the aid of permanent magnets. As every working electro-magnetic machine, as already previously stated, produces opposing currents, which weaken the electric current moving them, and as the direction of these currents is dependent on the direction in which the machine is turned, turning it in the opposite direction must on the other hand strengthen them. Exactly considered, therefore, every electro-magnetic machine when turned backwards becomes

dynamo-electric. That owing to this circumstance the production of dynamo-electric currents has not already long ago been accidentally discovered is easily explained by the special conditions of construction which must be fulfilled with electro-magnetic machines, in order that they may be applicable as dynamo-electric machines.

At first such dynamo-electric machines were constructed with my previously mentioned rotating cylindrical armature. It happened, however, that the iron of this armature became greatly heated owing to the rapid and powerful alterations of polarity. Later improved machines have been constructed by Gramme and von Hefner Alteneck, in which this disadvantage is obviated. No special commutation of the alternating direction of the induced current takes place in these dynamo-electric machines now generally used with unessential modification as in the old magneto-electric and dynamo-electric machines, but the alternating currents, which are generated successively in a continuous series of induction coils, unite in a branch or bridge conductor directly into a continuous similarly directed current. I had already made use of such a combination in a Volta-inductor, which was exhibited at the first Paris Exhibition in the year 1855, and is now to be found in the historical collection of the Berlin Post-office museum. These plate machines, so called on account of their shape, served to produce with a few cells currents of high potential such as are necessary for use on long telegraph lines. They were not suitable for the production of strong currents. The Gramme machine is in all essential elements identical with the magneto-electric machine constructed by Professor Pacinotti, which Gramme by rotating backward according to my contention made into a dynamo-electric current generator. It consists of an iron ring wound with insulated wire, rotating between the poles of a powerful electro-magnet. The wire wound in a closed circuit is divided into a number of equal portions, and provided at the points of division with contacts, which by rotation are brought into contact with fixed spring contacts, at two points diametrically opposite to one another. If these contacts are at right angles to the line joining the poles of the magnet, and if they form the terminals of a branch wire this takes up, as in the plate machine, the alternate currents induced in the two halves of the winding of the ring as a continuous current. Von Hefner's construction differs essentially from that

of Pacinotti-Gramme, in that the former does not like the latter use a ring wound with wire, but a solid or hollow iron cylinder, which is only wound on its outer surface with longitudinal closed windings. The separate divisions of these outer windings are so connected with the diametrically opposite sliding contacts, in a manner very difficult to understand without a diagram, that all the induced currents make their appearance as a continuous current in the outer circuit. Von Hefner's construction has the great advantage over the Pacinotti-Gramme, that in it the greater part of the wire wound on the armature is subjected to induction, and therefore active, whilst with the Gramme only the wire wound on the outer surface of the ring, and therefore only the half of it is active.

I have treated the dynamo-electric machine in its various forms more fully than others, because it forms the bridge to a wider magnificent development of the service which electricity is called upon to render to mankind. As I already drew attention in the first communication on the principle of the dynamo-electric machine, the possibility is given by its means, of transforming work in every instance into electric current, in order to use this for electric lighting, for metallurgical processes, for the transmission of power, and perhaps later for other still unknown purposes. Since that time twelve years work has been required to overcome the difficulties, which opposed the safe production and application of these strong currents, and in the future certainly much time and money must be spent, to make the further advances which are still necessary ; we can, however, even now assert with confidence that in the dynamo-electric machine we have a further important means of making the forces of nature useful in the service of man. This stands out specially clear in the advances, which electric lighting has made in recent times. There is hardly a large light-house now built, which does not use the electric light. By the assistance of the electric light, large ships at night and in fogs, seek to discover rocks which threaten danger and ships that may be encountered; by its means, steam tugs are enabled to find their way by night in rivers and canals. Electric light already illuminates many factories, workshops, and large halls. It plays an important part in offensive and defensive warfare, and has been everywhere widely used, where great brightness, the beauty of dazzling white light, and its

proportionately slight heat, as well as the absence of objectionable products of combustion are the first consideration. However, until a few years ago, a great obstacle still stood in the way of the universal extension of the electric light—its want of divisibility. Previous to that time it was not possible to arrange more than one arc with safety on one circuit. This is explained by the regulation of the mechanism, which governs the distance of the carbon points, between which the electric light appears, being worked by the strength of the current, which prevails in the circuit. If the arc is lengthened by the consumption of the carbons, its resistance increases, and hence the strength of the current in the circuit diminishes, and a corresponding approach of the carbons is brought about by the lamp mechanism. If however more arcs are in the same circuit, the strength of the current in it is dependent on the sum of the resistances of all the arcs, whereby it becomes indifferent how great the resistance of a single one is.

The strength of the current can therefore not be used for the regulation of the length of arc of the separate arc lights. In order to overcome this difficulty and make an unlimited division of the electric light possible, one has sought frequently, and down to the very latest times, to use as sources of light, in place of arcs, thin pieces of carbon or metal, which are made to glow by means of the electric current. The electric light so produced is however relatively very weak, requires much current, consequently much energy, and can hardly be called electric light. Jablochkoff made the first important step in the direction of the division of the electric light. He placed two parallel pieces of carbon near one another and filled the space between them with gypsum or some other refractory substance. Of such electric candles four or six can be placed in circuit, as the length of the arc is a fixed one for all.

In order to obtain a uniform burning of both carbons, instead of direct, alternate currents were used for the production of the light, as had been done previously when magneto-electric machines were used for the production of the light. These "electric candles" have decidedly contributed to the extension of electric lighting, but only imperfectly fulfil their purpose as all the candles go out when one is extinguished from any cause, and as the light does not then relight, which it does with electric lamps.

It was left for modern times to find a solution of the problem of the division of arc lamps by the use of mechanism regulating the length of the arc, and thereby to overcome the main obstacle, which hitherto opposed the general use of electric lighting. The regulation is effected by bringing in a shunt for each arc lamp. In the division of a current, the current in one branch is the stronger the greater the resistance in the other. If then the lamp is so constructed, that an increase of the current in the by-pass of the arc produces an approach of the carbon points, this must also occur through a lengthening of the arc taking place, and thereby each arc is kept to its normal length. I had already previously recognized this applicability of the shunt for the regulation of the electric arc, and used it in the construction of electric lamps; we have, however, to thank Mr. von Hefner who has already been mentioned, the head of the construction department of Siemens and Halske, for the successful construction of a lamp, which with the help of a differential action between the main and shunt currents has solved the problem in a very simple and perfect manner. By means of such lamps the imperial gallery at Berlin was for the first time lighted as an annexe to the Berlin Industrial Exhibition during the whole period of the exhibition.

The waiting room of the Royal East Railway and the buildings of the Imperial Diet in Berlin, the new Munich railway station and many private buildings have besides been already electrically lighted in this way. It has thus become apparent that the cost of lighting large open spaces, with at least three times brighter illumination of the ground, even with the use of gas engines, is only equal to the cost of gas lighting. I ought, however, here to remark, that the electric light will nevertheless with difficulty be able to supplant gaslight at any time. The great convenience, cleanliness, and unlimited divisibility of gas lighting, as well as the heating properties of gas, will always give it the advantage over electricity, where the great brightness which is to be obtained by electric lighting, the pure whiteness of the light, the slight heating and pollution of the air for larger spaces to be lighted do not speak decisively in favour of electric lighting. The use of strong electric currents for the transmission of power and for chemical transformations in metallurgy and chemical industry

have hitherto been much less developed than for lighting. In the Berlin Industrial Exhibition two examples of the transmission of power by dynamo-electric machines are shewn. A large loom and some smaller machines are driven by an electro-dynamic machine, which is set in motion through a leading wire by a similar dynamo (with the exception of the position of the spring contacts) set up in the machine room. There is further exhibited a narrow gauge railway, about 300 metres long closed on itself, round which travels a small electric locomotive with 3 passenger-carriages attached travelling at the rate of 3 or 4 metres a second. The rails of the railway form the one conductor to the large sized electric light dynamo in the machine room, whilst a conducting rail between the rails not in conductive connection with them, forms the end of the other conductor. The locomotive consists essentially of a machine quite similar to that producing the current, of which one wire is in conductive connection through the wheels of the locomotive with the rails, whilst the other communicates by means of a contact arrangement with the central rail. If the circuit is closed, and the current generating machine is running continuously at 600 to 700 revolutions a minute, the locomotive sets to work with great power and traverses the railway at a constant speed. The locomotive draws at its coupling with a force of about 200 kilogrammes when the wagon is at rest, and of about 70 to 80 kilogrammes when it moves at a velocity of 3 metres, which represents a tractive force of 3 effective h.p. It appears remarkable that this velocity only alters slightly, when instead of the usual load of passenger cars (with 18 persons), a double or even triple load is taken, and that the force of the first drawing is so considerable. But this is a special peculiarity of electrical transmission of power. In short its theory may be considered from the following points of view. If one assumes a dynamo-electric machine of Gramme's or von Hefner's construction on closed circuit set in rotation, the current and therewith the magnetism of the fixed electro-magnet increases to such a degree, as the special construction of the machine, and the inserted resistance allows of. The energy which is necessary to drive the wires wound on the rotating iron ring of the cylinder traversed by the current through the sphere of attraction of the magnet poles (the magnetic field) is proportional in the first place

to the strength of current in the wires, secondly to the strength of the magnetism, which within certain limits is proportional to the strength of the current, and thirdly to the velocity of the wires, or the velocity of rotation. As the strength of the current is proportional to this velocity as its producing cause, the work employed in the rotation must be as the third power of the velocity of rotation. The relation is otherwise, when a second equal or similar machine is inserted in the circuit. This is then rotated in its turn as an electro-magnetic machine by the current which the dynamo electric machine mechanically set in motion produces and then generates an opposing current as Jacobi already found, which diminishes the working current. If this work producing machine is of similar construction to the current producing one, the opposing current which arises is equally proportional to the square of its velocity of rotation. The final result consequently is a strength of current active in the whole circuit which is proportional to the square of the difference of velocity of the two machines. If c and c_1 are the velocities of the two opposed rotating machines, consequently the strength of the dominating current is proportional to $(c-c')^2$.

The work required by the current producing machine is then $(c-c')^2\ c\ k$, and the work produced by the work producing machine $(c-c')^2\ c'\ k$, in which k represents a constant dependent on the construction of the machines and the conductive resistance of the whole circuit. The calculation by maxima then gives, that the maximum of working effect occurs, when $c' = \frac{c}{3}$, whence it simultaneously follows, that by using the maximum of work only $\frac{1}{3}$ of the energy employed is utilized. On the other hand, however, the proportion of the expended to the produced work $= \frac{(c-c')^2\ c\ k}{(c-c')^2\ c\ k} = \frac{c}{c'}$, which means that the work made available increases proportionately to the velocity of rotation. The question what proportion of the work employed by electric transmission of power is available is consequently only to be answered thereby, that the loss of energy is so much less the more quickly the machine revolves, and that it would be equal to zero, if it could be turned infinitely quickly. It further follows from the formula, that the pulling force of the working machine rises

in a much greater ratio than the difference of velocity of the two machines, whence directly follows the small dependence of the starting velocity of the locomotive on the load to be moved, and the great force of the first pull. It must be here remarked that the above calculation does not take into consideration the internal friction of the machines, nor the variable resistance of the sliding contact, etc. which in some cases are of considerable importance.

Although many constructive difficulties have still to be overcome, and many inventions have to be made, before electric transmission in general, and electric railways or better tramways in particular can be brought into practical use on a large scale, the first results obtained must be considered as very satisfactory and promising. Under favourable conditions they can already in their present condition of progress be of good service. The application of strong electric currents, as they can now be produced by the use of energy, to chemical and metallurgical purposes has hitherto been much less developed. The application has hitherto been altogether limited to the galvanic purification of copper and its separation from gold and silver. And yet just for these purposes, the electric current should produce the greatest results, and be of the greatest service to mankind. The wide and promising territory of electrolysis of molten conductors is technically quite uncultivated, and neither scientific nor technical chemistry has hitherto properly honoured the analytical and synthetical power of the current. By employing energy with the help of the electric current, the closest chemical combinations can be decomposed, and the elementary bodies changed into other conditions and combinations in which the energy consumed is as it were laid up. The heat of combination of the water galvanically broken up into its elements represents the equivalent of the work consumed in the process. It is very probable that science of the future will learn to produce more easily handled fuel such as hydrogen by the consumption of work with the help of the electric current. Even the further step is not impossible of the production of food from fuel. There is no bolder flight of the imagination than to picture a future, in which mankind employ with the aid of the electric current the energy which the sun's rays convey to the earth in unmeasured amount, and which are available for direct disposal partly in wind and water-falls for the production of all necessary

fuel, and which learns to do without disadvantage without the coal fields so carefully stored by nature for its youth.

ELECTRIC HAMMER.*

The electric hammer has for its object the employment of the electric currents generated by batteries or machines as a driving force for the production of a forward and backward motion, which can be applied to the most varied mechanical purposes.

The apparatus which is shewn in the accompanying figure 165, consists essentially of a system of coils of wire A, B, C, inside of which a solid or hollow rod of iron or soft steel NS can be moved in the direction of the axis of the coils.

The middle coil is traversed by a constant acting continuous current, the purpose of which is to magnetize the rod NS.

The outer coils, A and C, which are wound with wire in the same direction, are on the contrary connected with an alternate current machine, or with a battery arranged for the production of alternate currents. By the action of the alternate currents traversing the coils A and C, the magnetized rod NS is moved backwards and forwards, for the currents alternating in their direction work upon it alternately attractively and repulsively.

The backward and forward motion thus produced, if currents of considerable strength are used, such for instance as produced by our dynamo-electric machines serving for lighting purposes, is so powerful, that it is available in the most manifold manner for the production of work, and can be used, for instance, as a forge hammer or rock drill.

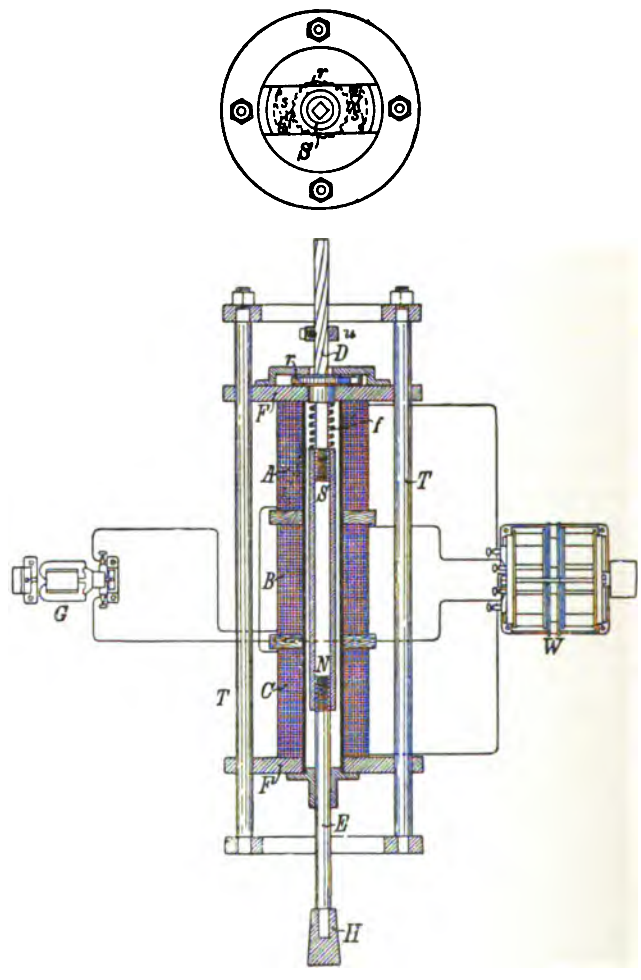
In the drawing the construction of the apparatus is shewn in section serving for both these purposes.

The hollow iron or steel rod NS does not fill up the whole of the hollow space formed in the interior of the coils A, B, C; it is rather shortened corresponding to the stroke which it has to make.

* (German Patent, No, 9469, of 22 October, 1879.)

To maintain it in its central position, guiding pieces D and E are attached to its two ends (which should not be made of iron or

Fig. 165.



steel) of which one serves to carry the hammer or drill H, whilst the other has an arrangement which effects the necessary rotation about the axis for drilling purposes.

This arrangement consists of a toothed wheel *r*, which is placed revolvable in the guiding plate F. Through a rectangular hole in the middle of the wheel *r* the guiding rod D passes, which is also rectangular, and is so twisted that it forms a long drawn screw thread, or rather a part of one. The wheel *r* is slightly revolvable in one direction, whilst in the other direction of rotation it is held fixed by the pawls *ss*. If the rod NS rises, the wheel *r* is turned by the screw shaped part D, whilst through a certain angle during the fall the wheel *r* is maintained fixed by the pawls *ss*, whereby the rod D is revolved as regards its axis.

In this way the rod is turned somewhat by each forward and backward motion, and so that after 10 or 20 strokes a full revolution of the axis takes place.

The apparatus according to its purpose is fixed in a frame in a suitable manner. In the application of the electric hammer to stone drilling or similar objects in which a sinking down of the oscillating iron rod occurs, we fix the connected three coils to the frame by powerful friction, and provide the rod with a stop *u* at a suitable point. If the drill H strikes the rock, the friction at FF holds the coils firm in their place between the rods T. But if the bore hole is so deep that the stop *u* strikes the upper metal plate of the coil system, before striking the rock, the blow effects the pushing forward of the latter. The iron rod must therefore always maintain the same relative position in the coils.

To limit the upward stroke and to apply its work to increase the downward motion of the hammer, there is placed under the guiding plate F, a spiral spring *f* formed neither of iron or steel, which acts against this as an elastic buffer.

The apparatus can work as desired in any position perpendicularly or horizontally inclined above or below, and only the frame which carries it and spiral spring *f*, described, must be suitably arranged.

The drawing shews the arrangement in such a way that for producing the direct current the middle wire coil B is connected to one of our dynamo-electric machines G, for the production of the alternate current, one of our alternating current machines W to the wire coils A and C. The machine G serves simultaneously as an exciter for the machine W, and both are set in motion by any form of motor.

The hammer or drill can be set up at a point distant from where the current is generated, and then the electric conducting wires, which lead from the current generating machines to the electric hammer, must be of a section corresponding to the length of the conductor.

Patent claims. 1. The combination of direct and alternating currents to bring about powerful oscillating motions of an iron or steel rod, by the application of three coils of wire, through the middle one of which a direct current passes, and through the two outer ones alternating currents.

2. In the case of rock drilling connecting the apparatus to its frame by friction and moving it forward by blows of the drilling rod when the rock is no longer struck first by the drill.

ON THE DYNAMO-ELECTRIC MACHINE AND ITS APPLICATION FOR WORKING ELECTRIC RAILWAYS.*

GENTLEMEN,—When formerly a problem was proposed to the electrical engineer, in which electricity had to perform heavy work, he was accustomed to say, electricity performs no manual labour, it is intended for fine work ; it commands, directs, it sets forces in and out of action, but to do hard work is not its business. In recent times this has been entirely altered. The dynamo-electric machine now serves us for the cheap production of electric currents of any desired strength. Electricity can therefore now enter into the list of hard working forces.

As the formation of the Electro-technical Society coincides approximately with the period of the perfect practical production of the dynamo-electric machine the managing committee thought it fit, that at the first meeting of the society an address should first be given on the dynamo-electric machine, and on a proposal, which I made already long ago, and which is already known to you all through the Berlin Industrial Exhibition, the proposal to

* (Address to the Elektrotech. Verein, 27th January, 1880.)

use electricity for the propulsion of vehicles or for working electrical railways.

It is well for me to begin by explaining to you why formerly we were not in the position to produce powerful effects with the electric current. We had indeed galvanic cells or batteries, we could enlarge them at will, and the belief that we should succeed, with their help, in producing electric motors which could compete with steam engines did not appear unfounded. As is known the German Diet had already offered a premium to the person who should produce the first serviceable electric locomotive. Professor Jacobi in St. Petersburg and Page in America especially have deeply interested themselves in the matter. The first has travelled on the Neva in a boat driven by electricity; he however himself explained on the completion of his experiments, that electricity was not suitable for the performance of heavy work, as it was too costly, and as besides many other technical difficulties apparently insurmountable to him opposed the solution of the problem.

That the work of the current of the galvanic battery must be disproportionately costly follows from the consideration that in the galvanic battery zinc is burnt in oxidizing acids. This is, however, a disproportionately more expensive fuel than coal, which burns in the oxygen of the air. Moreover the galvanic battery consists of metals and liquids, and the galvanic resistance of liquids is extraordinarily great. Galvanic batteries must therefore be of very large dimensions if they are to be of small resistance. Small resistance of the circuit is, however, an absolute requisite for the efficiency of electric motors; for otherwise the electricity is in great part converted into heat in the conductors and not into work.

Another source of electric currents is thermo-electricity. This electric force discovered by Seebeck of Berlin is often used for the production of weak currents, which serve to measure very slight differences of temperature and for similar purposes. Recently it has been attempted to build thermo-batteries of very large dimensions, and indeed very considerable currents have been produced from them. Unfortunately, however, the metals which form good thermo-electric elements are very bad conductors of electricity, and thermic batteries have therefore great resistance if they are not of very large cross-section. But even in that case

also the heat is carried quickly from the heated to the cooled junctions, thus causing a great loss of heat. Besides, large thermo-batteries arranged for strong currents have not hitherto proved to be constant.

The third method of producing the electric current consists in the application of the induction discovered by Faraday. May I be permitted for the better explanation of what follows to say a few words about the nature of induction.

Consider two closed circuits, for instance two wires the beginnings and ends of which are joined, of which one is traversed continually by an electric current. If now two parallel parts of these circuits are approached to one another, a current appears in the currentless conductor during the approach which is oppositely directed to the current existing in the other, and which continues as long as the motion of approach. If the circuits are then again removed from one another, an equally strong current appears in the currentless conductor but of opposite direction and therefore in the same direction as the primary current. A similar effect is produced when one approaches or removes two parallel portions of the same conductor traversed by a continuous current. In the first case an increase, in the second a reduction of the current takes place. As similarly directed currents, as Ampère shewed, attract one another, whilst opposite ones repel, it is possible from two such moving portions of a circuit to form an independent moving electro-magnet, or here better electro-dynamic machine, if at the moment of the greatest approach or removal by means of suitable mechanism such as a commutator, the ends of the moving portion of the circuit are exchanged, and therefore the direction of the traversing current reversed. Then as well on the approach as on the removal of the circuits work is done in the same direction by the electric current, but there also occurs in both cases a diminution of the existing current corresponding to it. This phenomenon occurs in an increased degree if the two portions of the circuit are wound round an iron core, and the poles of the electro-magnets thus formed are allowed to approach each other attractively or to recede from one another repulsively. Such an electro-magnetic machine moves and furnishes work, but causes at the same time a weakening of the working current reducing its performance, which traverses the windings of the electro-magnet. The same thing takes place

if steel magnets are used in place of electro-magnets round which continuous non-commuted currents circulate. With such machines there also occurs a reduction of the electric current traversing the moving electro-magnet equivalent to the work done. If such an electro-magnet machine with steel magnets instead of fixed electro-magnets, in the windings of which no current circulates, is rotated by some other force in the opposite direction to that in which it is moved by an electric current, the direction of the induced current is also reversed, a series of short induced currents of similar direction are therefore induced in the surrounding wires which must however be opposite in direction to that which a current must have, which should itself set the machine in motion. Such so-called magneto-electric current generators, soon after Faraday had discovered induction were constructed and much used by Pixii, Clarke, Stöhrer and others. They were afterwards improved by the Alliance Company, by myself and by Wilde, so that they generated currents of such strength, that they could be used for the production of electric light. These magneto-electric current generators have unfortunately several decided defects, which render them unserviceable for the safe production of very strong currents. In the first place steel magnetism is very much weaker than the magnetism which electro-magnets of the same size can produce; further steel magnetism increases in a much less degree than the mass of the steel used, and finally steel magnetism especially in large and powerful magnets is but slightly constant and is lost for the greatest part with time. Finally the great mass of steel, which must be used in such powerful current generators necessitates a large size of machine, and consequently large or a large number of electro-magnets, which again necessitate a great length of surrounding wire and consequently a great internal resistance of the machine. This, however, results in a great part of the energy of the currents being converted into heat instead of work. On all these grounds the magneto-electric machine is neither suitable for the performance of much work, nor for the production of strong currents.

This was the state of affairs, when, in 1866, the idea occurred to me that an electro-magnetic machine rotated in the opposite direction to that in which it was moved by a current traversing it, must produce a strengthening of this current. The idea lay close

to hand, as Jacobi had already shewn, that in every electro-magnetic machine worked by a current, an opposing current must arise which weakens the working current, and because, as above argued, the reversed motion must reverse the direction of this weaker induced current. In fact my supposition was not only confirmed, but it became apparent, that the magnetism remaining behind in the softest iron already sufficed to bring about the strengthening process of the exceedingly weak current produced by it. Already after a few quick revolutions, the current traversing the windings of a properly arranged dynamo-electric machine becomes so strong that the velocity of rotation must be diminished or external resistances or opposing forces must be inserted, in order to prevent the destruction of the machine by overheating.

In my communication to the Academy of Sciences of this place on the 17th January, 1867, on this new method of producing currents, I proposed for it the name of dynamo electric or dynamo machine, to express thereby that existing permanent magnetism was not required in it as in magneto-electric machines for the generation of current, but that in it work was directly changed into electric current, so that the magnetism produced only appeared as it were as a secondary product.

Already after the first satisfactory results I recognized and also stated in my communication to the Academy, that by means of this new source, new extensive technical fields were opened up for the application of the electric current. In fact the dynamo-electric principle enabled us to produce machines of comparatively small dimensions, which by means of the work employed enabled us to produce currents of any strength and directly to employ them in the Arts, or by means of analogous machines to again transform them into work.

A dynamo-electric machine according to this is nothing more than a properly constructed electro-magnetic machine revolved in the opposite direction, *i.e.* opposite to the direction in which it moves of itself by a current traversing it.

The great plans I formed already at that time as regards this new born child—as one is accustomed to do in the first delight—were not yet, however, capable of realisation. Already at that time I thought of an electric railway through Berlin, to reduce the traffic in the streets. The dynamo-electric machine was however

not yet ready, and had first to get over its diseases of childhood. As such appeared a new phenomenon, the heating of the iron by the rapid alternation of the magnetic polarity. The molecules of iron will not turn quickly enough, and it needed for this, internal work to be employed, which made its appearance as heating of the iron. The powerful machines which I had prepared for the production of the electric light, had on this account to be cooled with water, as the magnets and wires otherwise became too hot.

Then two inventions came to our help, which have much forwarded the matter. In the first place the Italian scientist Pacinotti invented what is called after him the Pacinotti ring. This is a surrounded iron ring, or in other words an iron bar, bent into the shape of a ring and wound with insulated wire. If such a ring is placed between the poles of an electro-magnet in such a manner that the plane of the ring lies between the concave polar surfaces, and it is then turned on its axis, constant currents are produced in the windings of the two half rings, which mutually destroy one another, when no leading away takes place. But if such a leading away takes place by means of sliding springs, which stand opposite to one another perpendicular to the line of connection of the poles, and come in conductive connection one after another with the divisions of the surrounding wires closed on one another, the currents of the two half rings combine into a single constant current, which traverses the lead off or shunt.

Through the Pacinotti ring we obtained a means of producing an induced current without change of polarity of the iron, and could consequently obviate its heating.

Gramme of Paris had the great merit of having first applied my dynamo-electric principle to the Pacinotti ring, and of having thus first produced a practically serviceable current generator for strong currents. One of the chief engineers of my firm, Mr. von Hefner Alteneck, very shortly afterwards solved this problem in a quite different and yet more satisfactory manner. In order to make this comprehensible, I must first explain that the portion of the surrounding wire lying inside the Pacinotti ring, produces really no inductive action ; consequently nearly half the wire of the Pacinotti ring is lost for actual working. Von Hefner Alteneck, however, uses in place of the ring, a complete cylinder, and surrounded it only outside parallel with the axis

with insulated wire. By an ingenious method of connection he has arranged that when the cylinder rotates on its axis between the poles of a magnet, currents similar in direction to those in the Gramme machine arise in the conductor connecting the spring contacts. The advantage arising from this construction is evident, namely, that with it no inner wires exist, which are not subject to induction. Von Hefner's machine has consequently less internal resistance with equal E. M. F., which is of considerable importance, and gives it especially for transmission of power an advantage over the Gramme machine.

These are the two machines on which the extension of the service of electric engineering depends. There are certainly many other constructions of dynamo-electric machines—in America alone a great number are patented—but all these are imitations or unimportant modifications of the two above mentioned, the Gramme and the Von Hefner machines.

The most extensive application which the dynamo-electric machine has yet found is to the production of electric light. This will probably be described at an early meeting of the Society. I will therefore here limit myself to the transmission of power and especially to the transmission of power in its application to the carrying of loads with the help of electricity.

As I have already explained, the dynamo-electric is nothing more than a properly arranged reverse acting electro-magnetic machine. When you therefore allow the current of a dynamo-electric machine to pass through the windings of an exactly similar one, this must revolve, and it must revolve in exactly opposite direction to the first. We must now consider what forces make their appearance, and what actions follow. The driven dynamo-electric machine acts then as an electro-magnetic one, and has the property of all electro-magnetic machines, of producing an opposing current, which has the tendency to weaken the current of the current-producing machine.

If we now assume two quite equal, resistanceless dynamo-electric machines connected together, and turn the one in the direction necessary for the production of the current, then the other would rotate in the opposite direction. As it has no resistance to overcome, its velocity of rotation must increase, until the opposing current, which it produces, is exactly as strong

as the current of the machine which sets it in motion. Then equilibrium would take place, no more current would pass through the conductor, and from neither one nor the other machine would work be produced or performed. But when you load the driven machine you thereby diminish first of all its velocity; as soon as the velocity diminishes, the opposing current thereby produced is also diminished; the conductor and machines must consequently now be traversed by a current which corresponds to the difference of the velocity of rotation of both machines.

This excess of current causes the current generating machine to offer resistance to the revolution, therefore it consumes work, and on the other hand makes the driven machine perform work corresponding to the strength of current and the velocity of rotation.

I have published calculations on this matter in another place; it would lead us too far to develop this. You see, however, already from the above theory, that the quicker the two machines run, the greater is the work which a current of a certain strength which traverses the conductor, produces, and the greater on the other hand naturally also the work, which is necessary to produce the current. One can therefore increase the work to be transferred through two machines by increasing the velocity of rotation to an almost unlimited extent, at least to the limit of velocity which may be permitted as practicable. It also follows from this consideration that a determined work can be obtained by a greater velocity through a weaker current, consequently by a smaller difference of velocity of both machines. As now the loss of work in the transmission of power, setting aside friction and the loss of current through heating the conductor is to be expressed by difference of velocity, it hence also follows, that the work will be transferred all the more perfectly the greater is the velocity of rotation of the machine. The question how great the loss of force is with electric transmission of energy, cannot therefore be answered positively. It is smaller the more powerful the machine, and the greater their velocity of rotation. But if the question is asked, With what difference of velocity of the driven machine is the transmitted work with a constant velocity of the current producer a maximum? calculation answers, that this with perfect dynamo-electric machines would be the

case at half the velocity of rotation of the driven one. By a perfect dynamo-electric machine, I here understand such a one, in which the masses of iron are so great, that the magnetism increases proportionately to the strength of current in the surrounding wires, and in which no further disturbances occur. On this supposition the work of a dynamo machine must increase as the cube of the velocity of rotation. This follows from the consideration, that the resistance to be overcome during rotation must be proportional to the strength of the magnetism and to the velocity with which the current conductors are moved past the poles. As the strength of the induced current is also proportional to this velocity, and from the above the strength of the magnetism produced by the current is consequently also proportional to the strength of the current, therefore also to the speed, the resistance to be overcome during rotation is proportional to the square of the velocity of rotation. The work required to overcome this resistance, is, however, in its turn the product of the resistance into the velocity with which it must be overcome. Therefore the work which the revolution of a dynamo-machine closed on itself continues, must be proportional to the third power of the velocity of rotation.

Experiments, however, teach that this is not so; the increase of the work proceeds much more slowly. There are various grounds for this. In the first place the resistance of the sliding contacts increases on account of the roughness of the surfaces with increasing velocity. Then the position of the commutator is of great importance. If the current traversing the windings is strong, there are two forces, which determine the position of the magnet poles. One is the magnetism of the fixed electro-magnet, the second the magnetizing force of the windings, which is exerted to place the magnetic axis perpendicular to its plane. There hence results a displacement of the position of the magnet pole in the direction of rotation, or in other words: I must place the sliding position not perpendicular to the connecting line of the poles of the fixed magnets, but I must displace it in the direction of motion. The velocity of rotation has the same influence for its part. This has indeed a remarkably strong influence, which seems to indicate that the velocity with which the magnetism in the iron moves forward is not unlimited.

These causes, to which may be added perhaps others not yet known, have the effect, as experiments teach, that the work which the rotation requires, does not increase as the cube of the velocity of rotation, but in a much less degree. If the first supposition were correct, then as already said a dynamo-electric machine which drives an electro-magnetic one would produce work in this, which would be greatest if the velocity of the driven machines were reduced to a third. With the magneto-electric machine the same calculation shows that the maximum of work takes place with a reduction to half velocity, the maximum of work well understood, which a machine of determined size can render not the maximum of transmissibility of work which depends on the slightest reduction of velocity.

From the numerous experiments we have recently made on the transmission of power, it follows, that with a proper velocity of rotation about forty-five to fifty per cent. of the work is transmitted as useful work. With a quicker rotation this useful work is raised to sixty per cent. of the work employed, therefore of 100 horse-power with which the current generating dynamo machine is driven, sixty horse-power would be given up again by the electro-magnetic machine.

According to my opinion, the question what percentage of the work can be electrically transmitted is not thereby settled; that is only a question of construction and velocity. Large machines driven at high speed will always have a higher efficiency than smaller machines at a lower velocity, and I calculate pretty certainly therefrom that one will arrive at 70 per cent., and even higher percentages of transmission of power.

At all events the calculation given by a French scientist that 50 per cent. would be the maximum which theoretically could be transmitted is incorrect. This is proved by the table of experiments shewn.

If one now says: Yes, but 50 per cent. loss is very large, I can only concede it conditionally. If one considers that the transmitter, therefore the working motor in this case is fixed and can be made as heavy and large as appears advantageous, that it can therefore be provided with as good boilers and heating as is necessary to obtain the greatest efficiency from the fuel, that this is not however possible with small engines, and especially with

locomotives, it follows that electric working even with 50 per cent. of loss is not less economical than working with locomotives. The expense of firing a locomotive, as I am assured by many competent authorities, is always at least twice as great as that of a good large stationary steam engine with large expansion and good boilers. I see my friend Schwartzkopff shakes his head; it may be that I have gone too far in this statement, but I cannot have made any great error.

If one however assumes this as correct, then electric transmission by a large fixed machine, even with 50 per cent. of efficiency, would not cause a greater consumption of fuel than a locomotive on rails with an equal performance of work. That, however, in my opinion is not so very essential. On the great lines of communication, on which our whole mode of life now depends, on the great railways, electricity will not compete with the steam locomotive just as little as the electric light in my opinion will completely drive out gas notwithstanding all American bragging. Electricity has quite its own sphere, both as regards lighting and transmission of power; it does not wish to supplant or put down, but it will only take upon itself such province as is badly done by the other existing contrivances that have been tried. For instance large spaces will be lighted by electricity, the air of which must not be heated and vitiated by a quantity of gas flames. For each gas burner produces nearly as much heat and vitiates as much air as a dozen persons. And so arise a number of cases where the electric light will give the most useful service which gas cannot furnish.

Electric transmission of power will also only arise in cases in which mechanical transmission cannot well be applied, and where there is no place for the steam locomotive, or it cannot perform the work. Thus it is of great importance for railway construction to be able to overcome steeper gradients with the trains than hitherto. Long costly tunnels might be thus quite avoided or shortened. Increasing the power of locomotives appears to have reached the uttermost limit, for the adhesion of the wheels is limited, and the weight of the locomotive cannot exceed a certain limit, for then the raising of its own load forms the greater part of its work. Also increasing the number of locomotives cannot assist for the same reason. Electricity would here

be able to render useful service, because it is practicable with its help, to divide the driving power itself among as many axles of the train as desired. And not alone in the ascent but also as a brake in the descent of the train could electricity be powerfully applied, as the dynamo machine renders equally good service as well for the production as the destruction of energy.

The second point is the application of these machines on light railways at the working places in mines, in tunnels, in the depths of shafts, where motors are placed above on the top and the working trains run down below. Here in the future the electric transmission of power will be of considerable importance.

A third application is the working of elevated railways. We are aware that the elevated railroad, or railway on columns, is frequently built in great towns; especially in New York it is already extensively applied. When in the year 1867, during the Paris Exhibition, I explained to an engineer of elevated railroads, my plan of building railways upon separate columns through the streets of Berlin and working them electrically, the idea rightly appeared to him as hardly realizable. But now after the Americans have carried it out in practice, since there both heavy locomotives and full trains run above on the columns, and no accident has occurred, the matter can be gone into with full confidence. For my part, I consider it an absolute necessity as regards large towns, to have a second line of communication for quick traffic besides the streets for carriages and foot passengers. You see how with the existing traffic our more crowded streets get daily more and more obstructed; they are sometimes hardly passable, and no constable can alter this. How will this be after 10, 20, 50 years? Statistics on the increase of traffic authorize us to say with the fullest precision, that the streets will in the near future not be able to carry it. A remedy must be found, if life in great towns depending on increasing traffic is not to be crippled, and the further extension of the chief town in the country is not to be completely stopped. A new line of communication must therefore be provided for quick passenger and goods traffic, which shall not hinder the street traffic or be hindered by it. For this purpose we are to have now the city railway.

But this only opens up a single line going through the centre

of Berlin. The inhabitants living in its neighbourhood have certainly the advantage of being able to travel by two routes; but the traffic extends in all directions. The city railway can in fact only supply a one-sided and insufficient service to the want of better means of traffic. In order to satisfy it, a net of similar railways would have to be laid throughout Berlin, the money for which would be hardly obtainable, and which would occasion tremendous re-constructions, and would disfigure the town itself in the greatest degree.

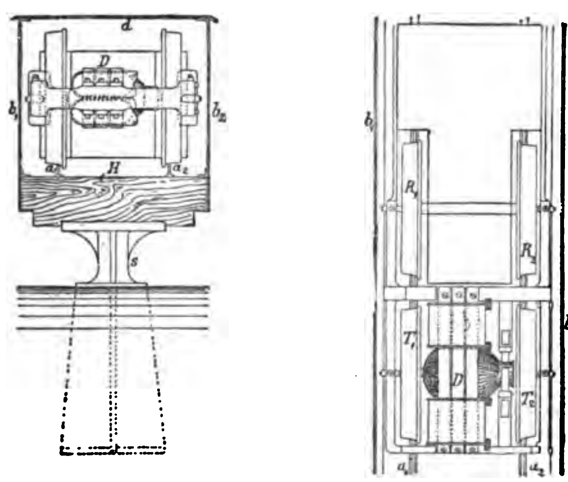
The same object would be obtained to a great extent much more simply if from all stations of the city railway, electric elevated railways were built north and south, which without stopping street traffic would bring the city railway in communication with all parts of Berlin, then indeed all Berlin would be opened up by it.

Another very useful application of electric traction would be the construction of small covered railways for great distances, which would do the same for great distances that the pneumatic post has done on a small scale, and for instance in the interior of towns. It is at present, as all gentlemen connected with railway affairs have informed me, a great tax on railways, that they must travel frequently and quickly only on account of the postal and especially the letter traffic. On the other hand it is of the greatest importance for letter traffic, which is still the basis of all traffic, to have the quickest possible communication between all places of traffic both at home and abroad. The pneumatic post fulfils this need for small distances, but it is only applicable within very narrow limits. Electrical transmission will enter here in order to render possible a quick traffic in letters also for great distances, as the pneumatic post does for small distances.

Such an "electric post" is diagrammatically represented in Fig. 166. It is assumed that the small covered line supported on low iron supports *s* is carried along the permanent way. If crossings or stations have to be traversed this is either done by sinking the railway in covered channels, or by raising it to the required height. To the supports sleepers half a metre long are fixed. These carry the sheet iron girders b^1 b^2 which are also half a metre high, which at the same time forms the sides of the iron covered line. Between these girders, light wooden beams

are fixed at suitable distances by angle iron to which the light rails a^1 a^2 are fixed. Of these rails the one is connected at frequent intervals with the girders which are joined above by a cover of iron plates which can be taken off separately, the other is conductively connected with all the iron pillars. Small four-wheeled wagons run on the rails with wheels 30cm. high, the axles of which consist of two parts insulated from one another. The rotating cylinder of a small von Hefner dynamo-machine

Fig. 166.



constitutes the one axle; each revolution of this cylinder therefore corresponds to a revolution of the wheels of the wagon. If a stationary current-generating dynamo-machine is then connected up at any place on the railway between the two rails, then the one rail together with the covering of the line forms one insulated conductor, whilst the earth together with the iron pillars forms the return conductor. The conducting connection between the rails and the wire wound on the driving machine is constituted by the wheels. As the resistance with a thickness of the plates of 3mm., which serves at the same time as cover, as girder, and as conductor of the electric current is only about 0·02 mercury unit per kilometre, it is sufficient to provide a stationary dynamo-machine for generating the current at every

20 kilómetres. As the carriages which constitute the letter holders are very light and their load also is not great, their axles

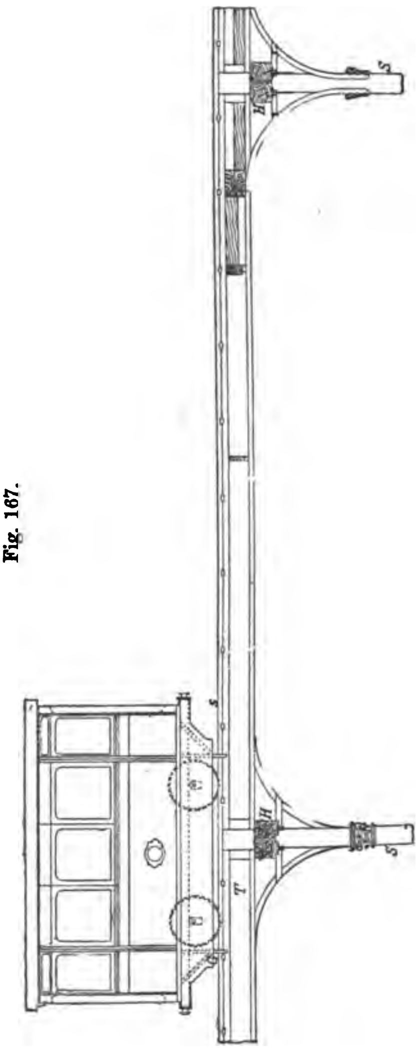


Fig. 167.

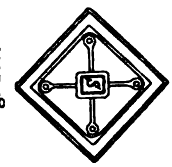


Fig. 169.

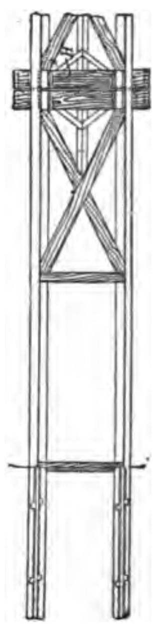
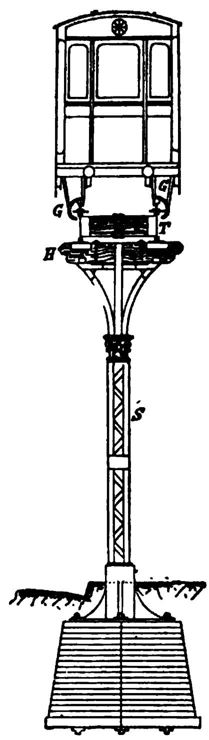


Fig. 168.

can make 800 to 1,000 revolutions, they therefore traverse the line at the velocity of railway trains. If the stationary dynamos

are considerably stronger than the motors, the velocity of a wagon will not diminish notably, when several wagons are simultaneously running on the line. Letter carriages can therefore be despatched at short successive intervals. The arrangements for the gradual reduction of the velocity and for the final stopping of the wagons at the arrival station can easily be arranged, and will be here passed over.

Fig. 170.



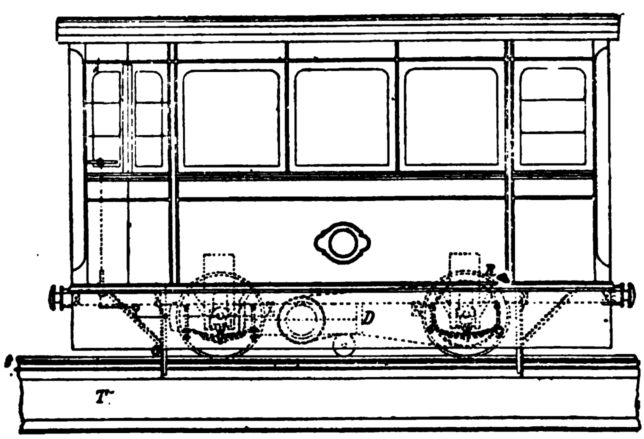
The cost of such a project will depend essentially on the price of iron. Owing to the present unusual inflation of the same, it can hardly be carried out on the scale proposed under £1,450 per statute mile.

Whilst I submit this proposal to public criticism, I will here only state in regard to it, that such "electric posts" are not restricted to railways, for on the one hand the nature of the dynamo makes it possible to overcome heavy gradients without corresponding reduction of the velocity, and on the other hand the requisite height of the line can be attained by giving a suitable height to the supporting pillars without need of levelling the ground. The "electric post" therefore permits places which have no railway connection to participate in the benefit of quick postal traffic.

We come to the second arrangement, that is the elevated electric railway proposed by me. Such a one is shewn in the following diagrams, Figs. 167 to 170. The wrought iron posts *S* are arranged at about 10 metres distance apart on the curb of the pavement where the street lamp posts are usually placed. They are 4·5 metres high, so that at street crossings even, the highest loaded wagons are able to pass under the girders T which support the rails. These girders T are 40cm. high and lie on beams H of hard wood, which are fixed to the posts. The lower rails *S* rest on the iron longitudinal girders. I pass over here the projected safety arrangements

against side movements, variations in the temperature of the iron, etc., which may be seen from the diagrams and may be considerably modified. What is, however, of importance is, that the longitudinal sleepers shall not be in metallic connection with the rails lying on them. The gauge is assumed to be 1 metre. On this run the passenger carriages shown on a larger scale in Figs. 171 and 172, which are constructed as light as possible for fifteen persons. It need only here be noted that each wheel has special bearings, and that the axle boxes of the wheels on either side are

Fig. 171.



connected electrically. Both driving wheels R are provided with pulleys *r* for belt driving, and receive through these their driving power from the dynamos placed below the body of the car. The belts can be tightened from the interior of the carriage. The ends of the surrounding wires of the driving dynamo are in conductive connection with the longitudinal supports carrying the current, and the rails through the wheels on the right and left side of the carriage. The electric resistance of the girders and rails is about $\frac{1}{90}$th unit per kilometre, and therefore only one stationary engine is required for an electric elevated railway traversing the whole of Berlin. Motors of 5 horse-power are assumed, which give the carriages a speed of 30 to 40 kilometres. The brake is applied by interrupting the current, but the usual brake

can also be applied in a very short time by short circuiting the machine on the carriage. Although in America the former safety arrangements against derailment of the elevated railway carriages have been thought unnecessary, here a catching arrangement G is proposed, which renders a fall of the carriage from the girders impossible even with derailment. These are strong iron catching arms which encompass the upper flange of the girder. The price of such an elevated railway depends also essentially on the price of iron. Although the cost of construction is high (about £12,000

Fig. 172.

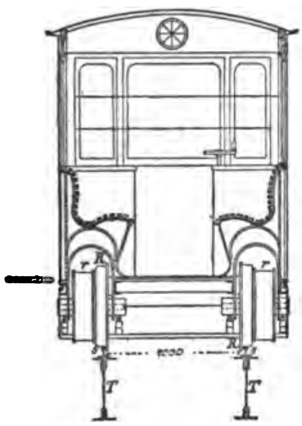
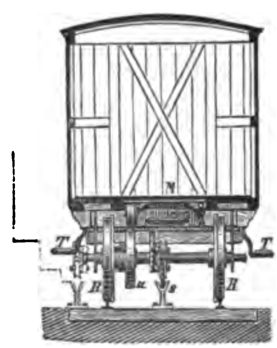


Fig. 173.

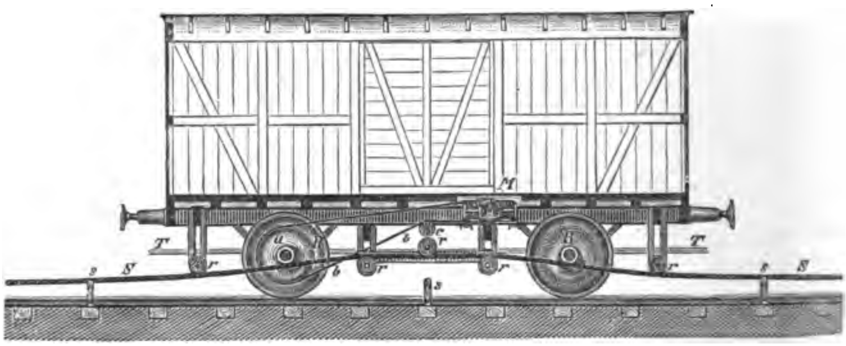


per statute mile), a traffic of five persons per carriage with twelve carriages in the hour makes the installation pay, in consequence of the exceedingly small cost of working the electric railway. I pass over the arrangements of the platforms, of crossings, etc., not to make too great a claim on your time, and will only remark that with the arrangement described as well as with the electric post, several carriages can simultaneously move on the rail, without the velocity being thereby reduced to any great extent.

Although it is not to be denied that an elevated railway traversing the streets has many disadvantages for the residents in the streets through which it passes, this disadvantage is decidedly outweighed by the advantage of quick traffic relieving the street. The construction of the railway itself can with

absolute safety be made so light and elegant that there can hardly be any question of disfigurement of the street by it. The electrically driven carriages are carried along so quickly and noiselessly without any other disagreeable appearance, such as the use of the steam locomotive brings with it over the confused traffic of the streets, that one will hardly notice them. As there will not be many stopping stations on the electric railway, these will be the natural starting and collecting points for tramway and omnibus lines, which, however, will give up the non-paying long routes. With their help and with the interposition of the railway,

Fig. 174.



the whole of Berlin would obtain a rational quick system of communication not burdening the streets, such as no other great town would be able to show.

Berlin is the birthplace of the dynamo-electric machine and the electric railway ; it should therefore anticipate the world with the installation of a system of elevated electric railways, which in the long run cannot be dispensed with. I ask you, gentlemen, to assist in the realization of this proposal.

Finally I have to discuss the application of the electric current of the dynamo machine as a supplementary power for locomotive lines. Such an arrangement which may be variously modified is shown diagrammatically in Figs. 173 and 174.

In the middle between the rails or better, quite close to the track, are placed fork-shaped supports of hard glass or wood well saturated with varnish, which carry a stout copper conducting

rope, which is stretched at the ends by springs. The wagons which are provided with driving dynamo machines in a similar manner to that described for the electric elevated railway, carry a system of rollers which take up the conducting rope from its fork-shaped supports in a similar way as in rope towing, and after the passing of the wagon replace it in the latter. The rollers, the number of which can be increased as desired, form the conducting connection between the rope and the driving electric machine, which can be fixed under the wagon and which turns an axle of the wagon by belting or other gearing. The return takes place by means of the iron frame of the wagon and of the wheels through the rails, if one does not prefer to employ two conducting ropes, and only to use these for carrying the current. A strong stationary dynamo machine, which is inserted between the copper wire rope and the rails, or otherwise between the two copper wire ropes, then serves to provide with motive force such a number of axles of the train as desired. In place of the wire rope there can be brought a solid conducting rail near to or over the rail insulated from the ground by hard glass or wood, and its contact arranged with the driving dynamo machine by means of a contact carriage running on the conducting rail, which is drawn after the train by a conducting rope. If the dynamo machines are to serve as a brake by the down-going train, the ends of the winding wires need only be brought into direct conductive connection with one another by means of a metal strap. They then act as current-generating dynamo machines, and heat the metal strip cooled by water. The work performed by the down-rolling train is then used for the production of steam.

With mountain lines having frequently changing gradients, the necessary delay for the picking up and dropping of the wire rope, etc., would be inconvenient. The steam producer and motor as well as the current-generating dynamo-machine, can be placed on a special wagon or connected with the locomotive. Any desired number of wagons can then be supplied with motors which are connected by means of conducting ropes with the current-generating dynamo-machine and are driven by it.

The dynamo-machine will serve through the transmission of

power, for yet many other railway purposes. I think I have, however, already made an immoderate demand on the patience of the meeting, and now only beg a kind and indulgent criticism of my proposals.

ON THE PROJECT FOR AN ELECTRIC RAILWAY.*

It is an agreeable experience for me, again to appear in the old rooms in which as a young man I have so often with pleasure been occupied, and I hope to follow the exhortation of the president, and to be able frequently to discharge my duty as a member of the Society.

I considered it my duty to bring to the notice of the public in general, and more particularly of a society which forms an essential factor of the public opinion of Berlin, before the Polytechnic Society, a question which is much discussed now, viz., the question of the electric elevated railway. It may appear somewhat bold to many to advance such a plan at all in a town like Berlin, which is so proud of its beauty. For it must be allowed, that all such arrangements do not exactly serve to beautify. On this account I should not have ventured, if I had not the firm conviction, that Berlin absolutely required it.

If one has observed for nearly half a century, how quickly the traffic of Berlin, which already ten years ago was very considerable, has increased, the question occurs to everyone ; what will come of this ? This cannot long continue so. Now, let us see how other great towns, which are older than Berlin, and have already a much more developed traffic, manage it.

There is first of all London. It has as a wide route for traffic, the broad Thames, which passes through the middle of it. Yet the traffic in the central streets has already increased to an intolerable extent. By the erection of broad viaducts and the carrying through of great railway constructions, which pass through the town in various directions, the enormous and still-increasing traffic could not be coped with. This was only effected

* (Address to the Polytechnic Society on the 11th March, 1880.)

by a whole network of underground railways, which is being further extended. The enormous traffic which is carried on by means of this underground network of railways has substantially disburdened the London streets again, and gives them that rest and order so characteristic of London life. The larger a town is, the more disagreeable it is in the middle of it, and the more places must there be outside of it, where one can live pleasantly and in better air. But the workmen's quarter must also be in cheap and quick communication with all parts of the inner town. Only in this way is an agreeable and healthy life possible in a great town.

Paris has its great underground system of sewers, these are long stretches and tunnels, by means of which the streets are to a great extent discharged; but Paris partly feels like us the load of an ever increasing traffic, and the endeavour, to provide the remedy, is already in Paris very much the order of the day.

If we now look at Berlin, we must say that our fathers, the fishermen, who lived in the villages of Berlin and Koeln, have so far made a bad choice, that they have settled on a place, where the water lies very near the surface. At a couple of feet below the ground we come upon surface water. In such a place certainly no great town ought to have been built; such a one should have been founded on such a height that a good underground communication could have been effected. Could that be done, all difficulty would be at an end, and Berlin could have extended without hindrance. This however we are deprived of; no builder will be so venturesome as to lay a line of rails in surface water, by constructions like the Thames Tunnel; the cost would be enormous and the result could not after all be perfect. Therefore there only remains the extension of the system commenced with the town railway, a network of real railways which cross Berlin in all directions. We have however observed the great destruction, which became necessary for the town railway, and many know the great expenses connected with the construction of such a railway. Nor does it add to the beauty, for the heavy viaducts over the streets, disfigure them greatly. I believe therefore that we cannot calculate on this system of elevated railway above the street level, it cannot be carried out for Berlin, and we are therefore placed under a necessity which compels us, to adopt a new way, to attain

a disburdening of the street traffic, and a quick connection of the centre points of traffic.

In New York the bold plan has been adopted of carrying railways for locomotives on columns through the streets, therefore building above the street itself a second network of roads or railways. There was first of all a project as here to carry the line on single columns, which stand in place of the lamp posts between the footpath and carriage way; such a railway now exists. and large trains with locomotives pass over it. Later the middle of the carriage way has been bridged over, and both tracks have been laid on this iron construction. New York is so situated that a considerable quick traffic along the water side is a necessity. Notwithstanding all the disadvantages, which these lines over the streets bring with them, the thing itself has almost become naturalized and the railways have a very large traffic. Many other towns have followed suit, and could not do without elevated railways, even if they wished to remove them. The trains follow one another every few minutes, and this railway has become the most usual means of communication.

A line of such difficult construction could hardly be carried out in our case. The pavements are very much freed by building it in the middle of the street, and the street traffic is not too much obstructed by posts. But it is not a pleasant arrangement. Owing to the great noise the trains make, to the smoke, the spray of water and the escape of steam, these railways are intolerable, so that they cause the most violent conflict with the residents of the neighbouring houses, who rightly will not put up with them.

This also interferes with the plan, which my firm has proposed to the town, to carry electric railways on posts, along the edge of the gutters, through the principal streets, which are most important for the traffic between different parts of the town; for everyone thinks of the American elevated railways, and imagines that it will not make much difference whether it is a locomotive or electric railway. People are alarmed at the noise which the trains make, the oil which drops, and other disadvantages. In consequence of this opinion among the general public, the proposal has been received very coolly. I believe however that when the matter is more closely considered, then especially the Berliners, who alone in the world have hitherto become acquainted with the

quiet management of an electric railway, must say, this is something different from a locomotive line, on which heavy engines with great trains thunder along.

However, before I come to details, I would give you a general idea by bringing a picture before you. Here is a project of such a line. You see a house front as it actually is, and in front the columns which stand in place of the lamp posts, 4½ metres high, so that they reach to about the window sills of the first floor.

It is not proposed to run long trains, but single carriages similar to omnibuses, each of which is driven by its own machine, which is shewn in another sketch. There is no noise in connection with such a railway, the carriages pursue their way without making themselves unpleasantly noticeable, and it cannot be said, that any thing disagreeable is connected with their quick passage.

It follows from two reasons that the windows cannot be seen into as has been feared; in the first place one cannot look from the light into the dark, and because when the lights are lighted every housewife in Berlin places curtains in front of the windows, and secondly because on account of the quickness of the travelling and the proximity of the houses, there can be no question of recognition.

It is proposed to let the trains travel at about the rate of goods trains, viz. 18 miles an hour; this is not a great but a safe velocity, which does not allow of the observation of near lying objects.

It has been further said the line would darken the shops and streets. This however is only very slightly the case owing to the breadth of our streets. The girders on which the lines rest are only about 1½ feet high, and have, seen sideways, only the appearance of a small band. The question of darkening will be reduced by choosing a correspondingly bright paint, by which the demands of beauty might at the same time be satisfied.

Besides, I do not think that a straight line is in itself, so great an unsightliness as some say, for then the stone edges of the gutter which now serve so much for beautifying the streets must be considered unsightly. These are all things to which the eye gets accustomed, and if the project is carried out it will not be long before the public has become so accustomed to the line, as

not to be able to do without it. Some few disadvantages which the railways in spite of expectation might bring to the neighbours will be richly outweighed by the advantages which they will offer them.

Frequent stations will not be made, but the line must always have the character of quick railway communication; it must connect directly the main centres of the traffic, and the stopping places will be used as the natural and necessary central points for the distributing traffic for the tramways and cabs. The idea that these will be injured by the line is quite erroneous. By quick means of traffic between the stations, local traffic is always increased, and in place of fewer local means of traffic more will be required. If this is already an advantage for the streets, it follows that by means of such a rail communication through whole streets a great need can be met. Any desired number of conductors can be fixed to the longitudinal girders, without their being seen, and the streets can thus not only be lighted electrically, but each householder or shopkeeper can easily be supplied with electric light or motive power, as he is no longer obliged to set up a special gas engine for the purpose. The machinery is fixed at a central point. There is also no necessity to make the arrangement for long; if the person it concerns does not require it any longer, the small branch wire is cut, and the light or motive power can be supplied to another. Electric lighting and transmission of power are therefore much more readily available for all who require them. It is the same thing with telephone connections; these also can be made much more easily. It will then not be so costly for the whole town to be covered with a telephonic network; this is much dearer when laid underground, and the town cannot endure the pavement being taken up at every moment to lay a new wire. After all, for all these purposes some conduit is required which can serve for all such conducting purposes. Therefore streets provided with electric elevated railways will become the electric progress streets, and I do not think, that in this way a diminution of the value of the houses will arise, but on the contrary these will increase in value.

According to the plan we have exhibited, and which we desire to follow, because it appears judicious to us, the stations of the town railway would be everywhere connected with radial branches

to the north and south. At present the town railway is a single line which goes right through Berlin, an advantage for all those that live in its neighbourhood, but only partially so for them, as they can go by it in two directions only, but not in all directions. But as people have occasion to travel in all directions, the needs of traffic are only partially satisfied by such a line. When, however, radial lines pass in all directions from the stations of the town railway something quite different will arise, then the town railway will be the great central artery for the whole traffic of Berlin.

It is all one whether the town railway will be driven also by electricity at a future time or by steam; if it is to serve its purpose trains must start every 5 minutes and the carriages of the electric railway must follow each other every 2 or 3 minutes, or according as traffic demands, so that every few minutes one may travel from any part of Berlin to any other part. Then we should have a system more perfect than any as yet existing; in a few years it will be a compulsory force, and Berlin would for once distinguish itself, in that it led and did not merely follow. (Bravo.)

I hope this at least, I mean that we have here to do with a serious traffic necessity, which increases from year to year, and that therefore it is worth going specially into the thing, and to fix one's eyes upon the possibility of its accomplishment.

I need not explain the electric railway in its essentials more closely. You have all seen the trials of it at the Exhibition and also heard the explanation. I will not therefore weary you with a theoretical explanation of the dynamo-electric machine, it has been largely printed, so that you will easily get information about it. I will only draw attention to one point, why we are now in the position to move heavy loads on electric railways, which was not formerly possible. In the year 1841 the German Confederation offered a prize for the construction of an electric locomotive; I believe this is the only premium which the former German Confederation ever offered. It was not solved although many worked at it, Jacobi of Petersburg and others. A property of the electric machine became apparent which made success unattainable; namely, that every electric motor, which is driven by a galvanic battery produces an opposing current, that this opposing current diminishes the power of the battery, and that

the quicker it turns the greater becomes the opposing current and the less motive power remains available. If I have a battery of 100 cells, and the engine begins to move quickly, there remains only the force of about ten cells, whilst that of the remaining 90 cells is balanced. It is as it were two horses which work against each other. This phenomenon led me to the construction of the dynamo electric-machine which in principle is nothing else than an electro-magnetic machine which is turned in the reverse direction; then the opposing current is added to the original and strengthens instead of weakening it. In opposing rotation work is consumed. This work is changed into electric current. Such a machine, which I described in a communication to the Academy in the year 1867, I have called a dynamo-electric machine, as it changes power directly into current and magnetic force is not as in the magneto-electric machine the origin, as here the magnet itself is first produced by work, and then again produces electric current.

From this other considerations arise, into which I can nevertheless not enter more closely here.

The girders of the electric elevated railway are formed of plate iron, and carried on wood so that they with their rails are insulated from one another, and do not make a noise with traffic. All parts, as is necessary in construction of iron, are calculated with surplus strength, so that even if carriages were placed all along the whole line, the deflection would not reach the permitted limit; it would be safe beyond all doubt.

There is still a question which is considerably ventilated. It has been said that if once an accident happens, everything would come to grief. Supposing a carriage falls down, there would be a velocity of fall of 30 feet, and that would produce a very violent concussion. That must naturally be avoided. The girders have broad heads above, and around these are strong constructions of iron, so that a derailment is absolutely impossible as the drawings laid before you show in detail. You see on them the strong bands which make a fall impossible unless the whole rail work were shattered. And besides it must not be forgotten that only light carriages are running, which can only produce a slight concussion, and that these will only travel at a moderate speed. It can be shewn by calculation, that this construction permits

of the carriages being stopped and a fall being rendered impossible.

This arrangement has however the disadvantage that it cannot be used with crossings. There rails must be kept on a level, and such projecting constructions cannot be used. The Americans first used them with their elevated railways, but have given them up. A locomotive has jumped over but the carriages have remained above. We however have no locomotive, but only carriages.

Another question is whether two carriages, of which one goes forward quickly and the other stops, cannot collide dangerously with one another. That can certainly take place, although there is a certain security in the circumstance, that when one carriage comes near the other, they mutually deprive each other of a portion of the electric energy and a diminution of the velocity takes place. We will however drop that for the present. There is in the machine itself a very powerful brake arrangement. When such a dynamo-machine is short circuited, the current becomes so strong, that the machine cannot carry it for long. It gets so hot that it must be spoiled. But that takes some while, and it is allowable to short-circuit the machine for a tolerably long time. Then a very powerful current arises, and considerable work is simultaneously consumed in the rotation to cause the current; this work is taken up by the wheels, which are turned by the machine and are coupled with it; therefore in a very short time a carriage which is running at full speed will stand still, when the ends of the conducting wire of the machine are brought into direct communication with one another.

There is besides the usual brake, and it is to be assumed, that each carriage has a conductor, who is at the same time ticket collector, and when it is necessary has to put on the brake. He looks after everything, and when he sees he is coming too near to another carriage, he must go slowly and apply the brake. Besides one is always dependent on the intelligence of the people who have charge of the mechanism; a mechanism cannot work safely by itself, but the means are fully there to prevent a collision.

Nothing can lie on the rails, not even snow or ice will be able to lie on them, and then it would be easily removable by clearers. If through malice any bar should be placed on it, it will be thrown

off and cannot get under the wheels. There are so many safety arrangements throughout that one can say there is no safer mode of conveyance than this. In the bustle of streets one is not without danger, how often are people run over, and do other misfortunes arise. On such a railway safety will at all times be much greater than in a swiftly driven carriage.

At the central station and at the other end there will be stationary engines, which are in connection with both rails, so that the one is positively and the other negatively electric. The current from one rail is transmitted by means of the wheels through the machine to the rail on the other side, and in this way it produces the power to turn the wheels. The rails have a very large section, so that the distance of 2 to 3 miles always offers but slight resistance, about $\frac{1}{3}$ of a unit; the carriages can therefore be sent regularly one after another. In order further to secure this, we propose to erect also at the other end of the line a primary machine; in this way it becomes possible for all the carriages to receive an equal impulse, and also that if one primary machine breaks down the working is still assured.

How many carriages can with advantage be allowed to travel simultaneously, experiment must decide; there is, however, what is the main point with new things, no sort of difficulty to be recognized, which could be disadvantageous to the scheme.

There is certainly much yet to ascertain and to construct. I will not say that the constructions in all respects are already final, but the principle is of that kind, that there is no theoretical obstacle to practical use, theory cannot be played with, if it forbids anything, practice does not help; but when the basis is secure, our industry is in the position to overcome obstacles, and so I believe we are in the position to take in hand seriously the building of electric railways through Berlin, where possible, so as to join the town railway, as then the town railway for the whole of Berlin will be a fact, which in its present form it cannot be, where it only fulfils quite a partial need. It would indeed be very pleasant, if in Berlin, which is the cradle of the dynamo-electric machine, the first railway of that kind was also built. Berlin should certainly take the lead in bringing forward into life what has been born here. Interest is everywhere shown in electric railways. I would, however, secure for Berlin the

precedence of having the first elevated electric railway. I think that Berlin is all the more entitled to it, as there is hardly a town which is so suited for electric railways, in the first place owing to the necessity of possessing a new means of traffic, which lightens the traffic of the street, and then because no other means is here available. We must determine on building an elevated railway, or cease to endeavour to be actually a great town. It has to be decided, Yes or No; there is no other choice.

I have had some photographs made of a model, which is here exhibited, which I now lay before you.

As regards the ascent to the stations, it would be best to rent the first and second stories of a shop at the desired places. This would form a waiting room, and would be connected with the railway by a light bridge. More than fifteen persons should not have seats in a carriage, and a train should go regularly every five minutes, so that a large collection of the public will hardly take place; it is therefore not necessary to arrange for any large waiting rooms. In open places one could arrange a staircase and gallery of light iron construction, to serve as a platform; in this connection no difficulty has arisen in America.

As regards the height of the line, that of the town railway is assumed as the standard. The expenses are certainly somewhat high; the construction must be very solid and firm; in this nothing can be economized; a first estimate has given the cost of construction from £12,000 to £16,000 per statute mile. That is certainly not cheap, but this cost would be balanced by the working, which is very cheap. A stationary engine supplies the power, which is provided with the best boiler arrangement for cheap fuel, so that the production of power will itself be cheap. If only half of this force is transmitted, yet it is always cheaper than a locomotive, the heating of which costs more than double that of an equally powerful stationary engine. The force, therefore, which is actually used is always cheaper than that of a locomotive. The conductor is also the engine-driver, by which the cost is much reduced as compared with tramways, and such-like means of traffic. According to calculation the system would soon pay a dividend, if a carriage with five persons were to go every five minutes, at a similar charge to that of tramways.

To avoid crossing under the town railway it is assumed that the

lines are only branch lines from the stations of the town railway There the lines would end. Besides the railway from Belle-Alliance-Platz and from Wedding to the town railway station later on other branch lines would complete the system.

As regards the question how the line is to be carried out with ascending and descending streets electricity is very adaptive; it is the difference of the currents opposed to one another which is available as tractive force. A slight difference in the velocity of the trains would greatly increase the actual tractive force.

ON ELECTRO-TECHNICAL AIDS AGAINST FIRE-DAMP IN MINES.*

GENTLEMEN,—The cause of this communication is the horror, which I and we all feel, when we read in the newspapers that many, often hundreds of human lives are struck down again in a mine by fire-damp. This happens with fearful regularity in the mines of all countries, and one does not note that anything effective has been done to obviate these unfortunate catastrophes, or see that in course of time greater safety is obtained. Electricity is very often a help in need, and it appears to me to be an important problem for the Electro-Technical Society to bring this question affecting humanity before it. I think that this also will not be without advantage, as in fact many attempts made a long time ago, but which have remained without effect, owing to the technical knowledge of that time not being yet sufficiently developed, now appear practicable. It is always well in such cases to undertake a revision from time to time, and to illuminate all that did not formerly appear practicable, with the knowledge and understanding of the present time. I should like therefore first to give you a short review of the causes of these fearful explosions, and the means which are applied to avoid them, so far as I, a layman, know it, for I am no miner, and can therefore consider

* (Address in the Electro-Technical Society on the 25th May, 1880.) 1880.

fire-damp only from a chemical and physical, and not from a purely mining standpoint.

Fire-damp consists as is known of mine or marsh gas, a combination of four equivalents of hydrogen and two of carbon. It appears as if in its formation a special chemical agent, time, plays the most essential part. In the course of long intervals of time, chemical actions take place, which we in the short space of time which is at our disposal in the laboratory, cannot imitate. Lignite, coal, anthracite, are produced in this order from stores of wood, which are carbonized in course of time, not by heat, but through the influence of time. In the course of time, apparently, water is secreted from the substance of the wood. This is decomposed at the moment of its becoming free, the oxygen has combined with carbon from the great carbon stores to form marsh gas, and thus the two dangerous kinds of mine gas are formed, asphyxiating carbonic acid, and combustible marsh gas, which, mixed with atmospheric air, forms the so-called fire-damp. Thus originated, it at once follows that no coal field can be quite free from it. It is even to be assumed that the greater part of the gases formed in the course of time—probably to be reckoned by millions of years—have by degrees disappeared through the overlying stone and earth layers, and that we have only to do with a remaining balance. Hardly any coal field can be quite free from it. When such a field is opened by a shaft or adit, and so brought into communication with the atmosphere, the gas, which partly condenses on the surface of the pieces of coal, and is partly found in the gaseous state in its existing pores, must get into equilibrium with the atmospheric air, and a corresponding outflow of the same take place. This development of combustible gas must increase with diminishing pressure of air. The great mischievous explosions of fire-damp therefore occur mostly after a considerable fall of the barometer. The light methane collects first at the roofs of the mines and then gradually mixes by diffusion with atmospheric air, which in some circumstances is accelerated by motion of the air. Then the danger first arises. The methane is indeed very combustible, but is only explosive if it is mixed with air, therefore with oxygen in sufficient proportion, so that a simultaneous combustion of the whole quantity can take place. It follows immediately from this

that it is hardly possible to obviate entirely the danger from fire-damp.

This can be attempted in three ways: one would be in principle altogether to prevent the gas from passing from the bed into the pit air. The second would be to make the exuding gas at once innocuous and before a dangerous mixture takes place; this can be effected by ventilation or combustion. The third would be a suitable signal system, which indicates, not only to the workers in the pit itself, but also to the officials outside of the pit, continuously and automatically, what is the condition of the development of methane, and its distribution in the pit, so that no people may be left in it when danger is anticipated, and they may be called back at the right time if it occurs during work. These are the three ways in which the enemy can be attacked, and the endeavour at least be made to render it innocuous. The best and most workable method will always be a good ventilation of the mine. This is always carried out and mostly with great care everywhere, and it is the means of obtaining the great masses of coal, without too great a loss of life. The second aid generally used is the employment of the beneficial invention of Humphry Davy of the miner's lamp. It depends on the extinguishing of flame when cooled below glowing heat. If the flame of a candle is held below a small-meshed wire netting, it only burns up to this netting. The wire netting withdraws much heat from the burning gas passing through it, and as the flame cannot exist without being at a glowing heat, it is extinguished inside the netting. If therefore a lamp is surrounded with good small wire netting, an explosion cannot pass through the netting, and will therefore not kindle the explosive gas on the outside of it. The miner can see from the peculiar jerking of the flame, that danger is present. This is a certain and readily applicable means which has saved the lives of thousands. Unfortunately, however, the experience of the last half century shows that it does not suffice; for, if it sufficed we should not have so many continued explosions, and the frequent accidents due to murderous fire-damp, which I must say to the disgrace of science and practice still so frequently occur in the world, should cease, or at least happen only seldom. But hardly a month passes, in which such a destructive explosion is not mentioned in the public prints.

This proves irrefutably, that the existing means do not suffice, and that others must be sought.

Already many scientific and practical men have busied themselves with this question, and have proposed other means. Davy himself, then Graham, a celebrated English chemist, closely studied the nature of fire-damp in certain pits, which were specially dangerous, and ascertained the chemical properties of methane. Graham * in particular has found that finely divided platinum does not act by catalysis on pure methane as it does on other hydro-carbons. Graham's authority has been the reason, why finely divided platinum has remained out of use as a means of indicating the existence of methane down to the present time. Payerne † in Paris certainly made the proposal in the year 1847, to erect pumps in the pit, which should pump the air through large diaphragms which were covered with platinum black or platinum sponge. He says, in opposition to Graham and Dr. Ure, that methane would burn slowly through the contact action of finely divided platinum, and thus dangerless purification of the air from methane would take place. This proposal has not been followed up. Probably it is the costliness of the necessary quantity of platinum which has rendered it impracticable.

In the year 1868 Delaurier ‡ made a quite original proposal to the Paris Academy on the safety of workers against explosions of fire-damp. He proposed to lay an insulated wire through the whole pit, which should be made thin at different parts, and covered with flowers of sulphur. Before the miners entered the pit, the current from a strong galvanic battery should be sent through the wire. This would heat the thinned portions of the wire and kindle the sulphur, which in its turn would explode the fire-damp, if any existed. If no explosion took place, the miners could enter the pit with safety. This proposal, testing by explosion before the entrance of the miners into the pit, appears well worthy of attention.

The third method proposed consists in organizing a good signalling system, which affords the necessary means of perceiving

* Chemical Gazette, Dec. 1845, No. 75. Dingler's Polytechniches Journal, Vol. 99, p. 138.

† Dingler's Polytechnisches Journal, Vol. 103, p. 153.

‡ Dingler's Polytechnisches Journal, Vol. 190, p. 339.

the danger at the right time, and of removing it by properly arranged ventilation, before the gas mixture becomes explosive.

Ansell in London proposed in 1867 * to diminish the danger of fire-damp by setting up apparatus, which by electrical means should point out the collected methane, in the pit as well as outside of it. His apparatus depended on the phenomenon that many materials, such as india-rubber, marble, &c., are impermeable to atmospheric air, but easily so to methane and many other gases, hence if an india-rubber bladder filled with air is brought into a space filled with methane, the latter must stream in through the wall of the india-rubber, and in consequence expand the bladder. Ansell therefore constructed an apparatus, by which the increase of pressure produced by endosmose, in the interior of an air space closed with an india-rubber or marble plate, was employed for bringing about a contact, by which an electric warning signal was given at any desired place. This ingenious proposal has so far as I know received no practical application. Perhaps this circumstance was in fault, that a collection of carbonic acid also acts osmotically like methane, hence it could not be known for certain which gas was indicated by the apparatus.

Dr. Van der Weyde proposed in 1870 † a modification of Ansell's apparatus, whilst A. Winkler proposed in 1879 ‡ to make frequent analyses of the methane occurring in the air of the pit, by determining the diminished specific gravity of the pit air, owing to the methane mixed with it. Lastly an anonymous writer signed A. P. in 1877,§ proposed by means of continuous induction sparks, to ignite the combustible mixture of atmospheric air and methane in a vessel enclosed with wire cylinders, and by means of the resulting explosion to establish a contact, which should give a danger signal.

Latterly a student of the name of Körner in Freiberg has taken a German patent, No. 6,179, for an apparatus, which depends on the slow combustion of methane by finely divided platinum (platinum black or sponge) which was denied by Graham, but employed by Payerne for his proposal, who

* Dingler's Polytechnisches Journal, Vol. 183, p. 552.
† Dingler's Polytechnisches Journal, Vol. 196, p. 513.
‡ *Ibid.*, Vol. 231, p. 280.
§ *Ibid.*, Vol. 226, p. 510.

maintained it in contradiction to Graham and Dr. Ure. He means to use the heat, produced by this slow combustion, to heat a mercury thermometer, and to avail himself of the rising mercury column, for the production of contacts in the same way as Ansell employed, to give signals of threatening dangers. I will not enter more closely here, on the somewhat complicated telegraphic mechanism to indicate outside of the pit, the number or the place of the apparatus announcing the danger.

As follows from the above historical summary of the proposals hitherto made that have come to my knowledge, to guard against the frightfully great loss to life and property which are occasioned continually by fire-damp, besides ventilation and the safety lamp, there are yet other means either to prevent the collection of fire-damp to a dangerous extent, or to give information of the danger at the right time, and thereby to prevent losses. So far as I know these have never hitherto been applied in practice. It is possible that experiments have been made with some of these proposals, and that the same have not proved satisfactory. But if the theory is correct, a few unpromising experiments should not throw cold water on it, as practical difficulties can almost always be overcome. Besides electric practice in recent times has made special advances, and much can now be easily and safely carried out, which formerly frustrated all efforts. It is therefore well worth while to test the question of the increased safety of coal mines against fire-damp in connection with proposals hitherto made, and having regard to the present standpoint of engineering.

The possibility of preventing the evolution of methane in general by the production of a permanent surplus pressure throughout the whole of the mine, is indeed hardly to be questioned, for already the slight alteration of atmospheric pressure is so very remarkable. Probably an excess pressure slightly exceeding these fluctuations would suffice, not only to prevent every evolution of methane, but on the contrary air would be frequently driven through the coal beds, and these be thereby gradually freed from methane. But whether actually by powerful ventilation, and suitable blocking arrangements, an excess pressure can be produced in the pit, will first have to be established in each separate case. As a rule probably it will not be possible to carry out this method. The

uninterrupted freeing of the air of pits from methane proposed by Payerne by repeated forcing through finely divided platinum is still less feasible for general application. The great variation alone of the evolution of methane, to say nothing of its costliness, would make this method inapplicable and even dangerous. The method proposed by Delaurier to make at different parts of the pit galvanic explosion tests before the entrance of the workmen into it, is on the contrary worthy of notice as already remarked. This could be carried out with greater safety and with proportionately less labour and cost, with the present widely developed state of galvanic means of exploding. Truly protection against explosions during working would not always be thus attained. In order also to obtain this, at very many and especially the high lying and particularly exposed places, there would have to be igniting places, as for instance open flames always certain to act. The light methane always in the first instance collects on the roofs of the inner spaces (adits, etc.) of the pits, and mixes gradually through diffusion and currents of air with the atmospheric air into an explosive mixture. If it is ignited, before this mixture takes place, an innocuous quiet burning of the gas takes place, which gives the workmen time to withdraw. To secure the pits against explosions by many open flames brought near the roof, and at the same time to illuminate them, has been already proposed so far as I know. Gas, petroleum or oil flames, however, quickly consume the oxygen of the air in the pits, and mix with their non-breatheable products of combustion. The same object would be gained by means of electric illumination, without this disadvantage. At present 20 or 30 small electric lights can be placed on a single circuit which can be supplied from a machine above ground, and can at all times be simultaneously lighted and extinguished. The proportionally slight cost of this pit illumination would be more than balanced by the better and quicker work with brighter illumination. If the lamps are lit sometime before the entrance of the workmen, and are kept alight during working time, hardly any great misfortune will have to be registered on account of fire-damp. In many cases indeed the not altogether inconsiderable cost of the first installation, the slight thickness of the coal beds, and the great extension of the field of work will not allow of the application of this method of

safety. The proposals of Ansell and Körner further present efficient means for the prevention of accidents by fire-damp. Both proposals amount as already stated to setting up at different and especially at dangerous portions of the pit instruments which indicate the appearance of methane, both to the workers employed in the pit, and to places outside it. If the apparatus are certain to act under all circumstances, and if they are arranged in sufficient number and in the right places in the pit, then the security given by such a system of control will be a tolerably sufficient one. Ansell's annunciator for methane acting by endosmose can be set up very simply and cheaply. You see before you such an apparatus which simply consists of a metal ring, the openings of which are closed by an india-rubber membrane. One of these membranes is provided at the centre with a little piece of sheet platinum to which a wire is soldered which leads to a terminal. Nearly opposite to the little platinum plate is a contact screw, which is in conductive connection with another terminal. If the air in which the little apparatus stands becomes saturated with methane, this latter penetrates through the india-rubber and increases the volume of the enclosed air. The little platinum plate therefore comes into contact with the contact screw, by which the circuit, to which the apparatus was connected by means of its two terminals, is closed. If a galvanic battery and one or more bells are inserted in it, these will sound and show danger. If to each of these apparatus a special conductor is connected up to the surface, or if at least the apparatus is divided into groups, of which each has its special leading wire (using the earth as return circuit), it may be at once discovered which apparatus or which group has given warning of danger. It may be mentioned as a defect .in this arrangement, that on the one hand there is a doubt whether methane or carbonic acid gas has given the alarm signal, as well as on the other that after removal of the gas mixture giving the alarm a considerable time elapses before the gas which enters is again driven out by exosmose, and the contact thereby again automatically broken. The Körner apparatus is free from these two disadvantages, as it depends on the heating of finely divided platinum through slow combustion of the methane. On the other hand it must appear doubtful, setting aside the unnecessary complicated construction of the indicating apparatus, whether the heating of the platinum black by small quantities of

the mixed methane would take place with certainty under all circumstances. As already mentioned, the celebrated Professor Graham, the discoverer of osmose, found in his experiments on pure methane, which continually streamed from one place in a coal pit, that it does not burn slowly by contact with cold platinum black, like other hydro-carbons and hydrogen, and mentioned this as a means of distinguishing methane. Payerne denied this, without, as it appears, having found credit with the chemists. I at least have not become aware of further decisive experiments. A series of experiments, which Dr. Fellinger has carried out in my laboratory have now however definitely proved that pure methane produced from lead acetate in fact combines with oxygen by the catalytic action of platinum black, even if the platinum black is not heated, just like hydrogen and other gaseous hydro-carbons. Besides the catalytic action of platinum black is constant to so great an extent as to render it applicable to the construction of a methane annunciator.

Less serviceable than endosmose and catalytic action of platinum appears to be the method proposed by Winkler in 1879 of the indication of methane by determining the reduction of the specific gravity of the pit air. In the first place weighings of that kind require very exact determinations with large balloons, which are very difficult to apply in damp narrow pit galleries, and to maintain in order, and secondly fluctuations of atmospheric pressure and of carbonic acid quite falsify them. But both the Ansell and Körner methods of testing for methane have the disadvantage that they, setting aside disturbances, prove only a certain degree of admixture of methane. As a slight admixture of methane even with the most powerful, fully sufficient ventilation cannot be entirely avoided, the apparatus only indicates, whether the permissible degree of mixture is exceeded or not, but give no certain indication in what degree it is the case, and whether the admixture of methane increases with threatening speed or remains constant. This can be obtained in a very satisfactory manner by using instead of the ordinary mercury thermometer, as Körner did, thermo-electric elements. You see here three such elements of which one side is covered with a thin layer of platinum black. Each of these elements communicates through a leading wire with common return conductor with a galvanometer, which in practice would be fixed in the pit house. As soon as a small

quantity of methane or common illuminating gas is brought under one of these bells, beneath which the thermo-electric elements are placed, the corresponding needle is deflected. The amount of the deflection now constitutes a measure of the quantity of methane mixed with the air. If a series of such thermo-electric indicators is assumed to be arranged in suitable places, and the conductors to end in the pit house, the deflections of the galvanometer give a true picture of the actual mixture of methane in the different parts of the pit. The engineer in charge can therefore set the ventilating apparatus at work, in order to prevent an increasing mixture of methane, or in case actual danger already approaches, to give an electric bell signal, which calls the workman back from the pit. As is shewn by the arrangement brought forward, the osmotic and catalytic methods may be combined and the one used to control the other. The osmose indicators would then be so placed, that they first announced the actual arrival of danger by sounding bells in and out of the pit, whilst the catalytic indicator by the deflection of the galvanometer needle showed, that the mixture of foreign gas consists of methane or some other combustible gas and not of carbonic acid, and shows at the same time the place and character of the accumulation of the dangerous gaseous mixture. The disadvantage of the thermo-electric indicator in comparison with the Körner proposal, viz. that it necessitates a great number of insulated conductors, is less important in the present state of technical science, as a great quantity of sufficiently insulated conductors can be combined into a cable at comparatively speaking small cost. Even if no mechanical arrangement acts quite certainly, and consequently through the proposals made no absolute safety against fire-damp is to be obtained, it yet appears quite evident, that the safety of pitmen is increased in a very great degree by the methods described. The Electro-technical Society will often it is hoped have to busy itself with this important question. If this suggestion brings it about that the question of greater safety against injury through fire-damp is taken into close consideration and it is recognized by it that besides ventilation and Davy's lamp, there are other means, to all appearances practicable, and that it is a duty to test their practical applicability, an incontestable advantage has been gained.

MACHINE FOR THE SEPARATION OF MAGNETIC AND NON-MAGNETIC ORES.*

GENTLEMEN,—It is properly speaking a very old question, about which I wish to address a few words to you. The well known and frequently used power of the magnet, to attract iron, has been used in industry about as long as magnets have existed. Iron has always been removed by steel-magnet combs from shavings; to pass over at once to the very latest times, since the introduction of grinding with cylinders instead of with stones it has been the custom to use magnets in flour mills, in order to remove pieces of iron from the corn, as such a piece of iron falling in, would destroy the cylinder. As a rule it is so arranged, that steel magnet combs are fixed behind one another in different positions, so that the substance in question falls from one comb to the next; the iron remains resting on the combs and is then wiped off from time to time. Cylinders have also been made, which consist of genuine magnets, the poles of which are directed outwards and on which the corn to be cleaned is allowed to fall, and which are turned round so that during the rotation the iron remains attached, and is then removed by brushes. This acts very well, but is only applicable where powerful attracting forces are available, therefore where metallic iron is to be removed, further where no great quantities are to be treated, for this process is rather complicated.

I was induced to construct the apparatus by a Belgian company who worked zinc ore in Spain, and who there crushed a calamine ore, enclosed in an iron ore, I believe a spathose ore, which is very difficult to separate from it, so that the crushed pieces consist of a mixture of spathose ore, and calamine; these could not be separated from each other by any mechanical dressing; the whole of the iron had to undergo the distillation process, and that required much coal, which is very costly there. The director of the company came to me and asked, whether we could not make him a machine, which could separate the ore, about 20 tons daily. I first of all declined, but

* (Address to the Verein zur Beförderung des Gewerbfleisses on the 7th June, 1880.) 1880.

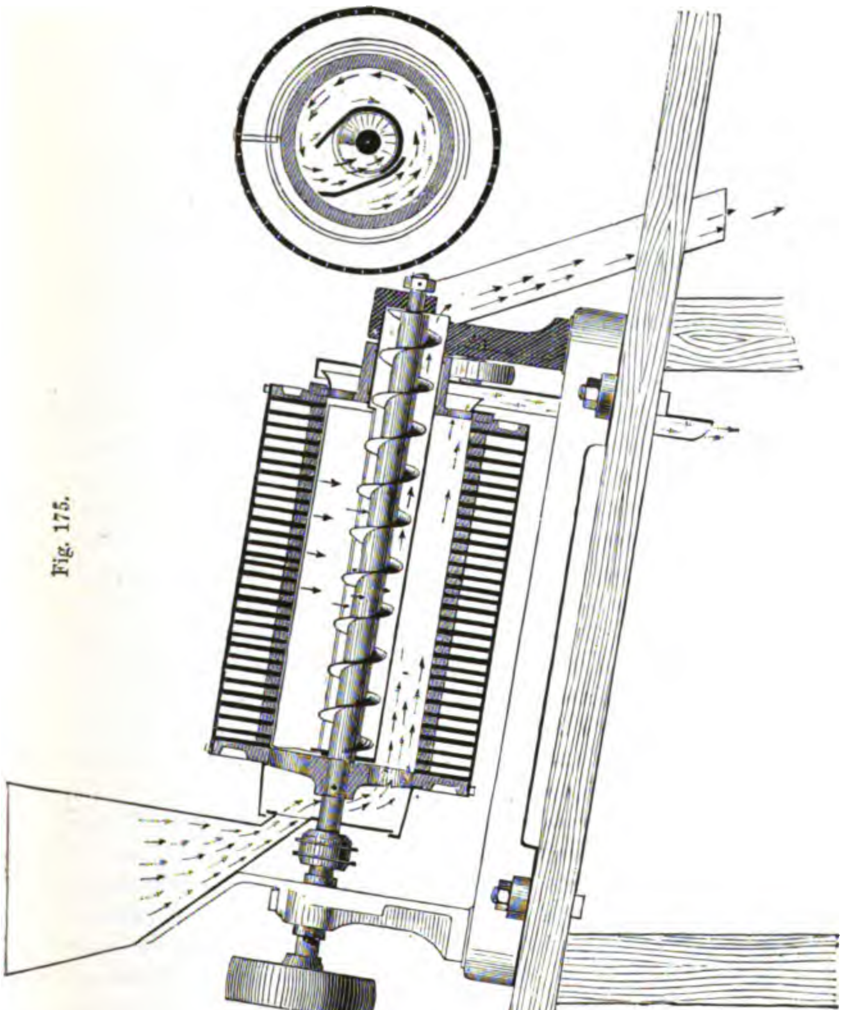


Fig. 175.

the gentleman insisted, and we made an agreement which guarded the interests of both sides. Then I thought out the question further, and have so arrived at this machine.

When we consider the technical points we find there are three important ones which our construction must embody. The magnets must only hold what comes into their immediate proximity; if made too strong they would also hold non-metallic pieces; and therefore the magnetic attractive force must not be too strong. It is further necessary to give the magnets abundant opportunity for selection, so as to bring all parts of the mixed ore passing through into actual contact with a magnet pole. Therefore many magnet poles must be provided, and these must be arranged with opposite poles presented to each other, so that by magnetic induction the adherence may be increased, and so larger pieces may be retained. A second principle must be, that the removal of the magnetic pieces takes place continuously, above all things the whole process must be continuous, otherwise large quantities cannot be treated; electro-magnets which become alternately magnetic and non-magnetic cannot be here employed as these require too much electric work, and do not produce apparatus which can do much work, therefore an arrangement must be made so that what is held fast by the magnets is continually wiped off. Now you see here a machine, which I have constructed upon these bases (fig. 175). It consists of a somewhat steeply inclined axle provided with a screw thread, around this screw thread a fixed brass tube is placed (the axle is of steel, but the screw and tube of brass), the tube is slit above and bent and provided with a striker, which lies tangentially inside on the magnetic hollow cylinder; this hollow cylinder consists of plain iron discs, which lie near together, and are separated from one another by brass rings lying between them outside. These iron discs are connected by iron bars so that they form peculiarly shaped horse-shoe magnets, the ring-shaped poles of which form the inner wall of the hollow cylinder. The magnetization is effected by insulated wires, which are wound on between the discs before the fixing of the outer iron bars. The first space has, for a reason to which I shall refer later, only a few windings, the next more, and only at the end are they wound completely full. By means of the electric current traversing the windings a regular sequence of

north and south poles is produced. We have therefore a smooth cylindrical surface, which consists of plain ring-shaped north and south poles, lying close to one another. The hollow cylinder thus formed of magnetic discs of alternating polarity is connected at the one end with the axle of the apparatus by means of a disc, and at the other it is carried on the fixed inner brass tube. The material to be separated is fed into the first end of the hollow cylinder, and then slowly passes through the somewhat obliquely placed rotating cylinder. It must then pass the rotating ring-shaped magnet poles, which take hold of the magnetic parts, and carry them up where they are caught by the striker, and thrown into the fixed inner tube, from which they are screwed out by a screw. If at the commencement there were too strong a magnetic power, all the magnetic material would stick fast in too great a mass at this point; the whole space would be filled, and the separation would be already entirely effected here at the first ring, or, if this could not be done, the apparatus would not be able to turn out what it should; and therefore the arrangement is made that the magnetism should gradually attain its full strength, so that by the passage of the ore through the rotating hollow cylinder always increasing magnetic forces act on the magnetic portion of the mixture. How powerful the current is to be made depends on the nature of the ore, and the amount of its roasting. The current of a small dynamo or magneto-electric machine is generally sufficient, as the new form of electro-magnet which is here used, produces very strong magnetism. It has been found, that the calamine to be separated from the iron ore also contains some iron, 5 to 10 per cent. with complete roasting; this quantity of iron is sufficient to hold the calamine fixed to the magnet poles, if too powerful currents are used. There is no actually exact separation, as the iron also contains a little zinc. On this account the current must be so chosen, that the desired proportion of separation may be attained; this can be arrived at, by rotating the current generating machine proportionately quickly.

It appears to me, that such a machine is at the present day not without value, not alone for the special occurrence of ore for which it has been constructed; I mean that there are also other cases where it is desirable to separate magnetic from non-magnetic

ores or other substances. When the small apparatus shown here full size is used, it gives already 1 to 2 tons an hour. As the machine can be made larger at will, much greater quantities could also be worked with little trouble and small cost.

Another point is its use in flour mills. I have recently read a notice in an American journal, that some one had made a similar machine there, which showed the surprising fact, that there was so much iron in corn, that one could almost start a forge with the iron. It would be, indeed, a small matter, if the corn straight from the dealer were allowed to pass through such a machine, and so the danger be overcome, which there is for the mills when there is iron in the corn. I think, therefore, that the machine is of general importance. In my opinion, also, the construction is as simple and correct as possible. One can hardly think of it as other than a tube, through which the material quickly passes, and which rotates quickly, to give all the molecules an opportunity of touching the magnet poles. In practice the machine has operated well, the purchasers had sent a ton of their ore, which in the space of an hour has been completely separated.

ELECTRIC PLOUGH.*

In the mechanical or steam ploughs hitherto used it is necessary that the ground to be worked should be quite level; further, the existing constructions do not render it possible to draw furrows deviating from a straight line and presuppose a level, regular, and usually rectangular form of field to be ploughed. The electric plough, which is the object of the present invention, has in view the removal of restrictions appertaining to those implements, and renders it possible to plough fields of any size, with uneven surfaces, in any desired straight or curved directions, by means of a stationary motor even at some distance, or a locomotive set up as desired.

* (German Patent, No. 12869 of 12th September, 1880.)

The electric plough is shown in side view and plan in the accompanying figures 176 and 177. The frame G rests on three wheels, R_1, R_2, R_3, of which the first two are placed on the main axle A, whilst the third is made to turn, so that the carriage can be directed by its means. The power for propelling the plough

Fig. 176.

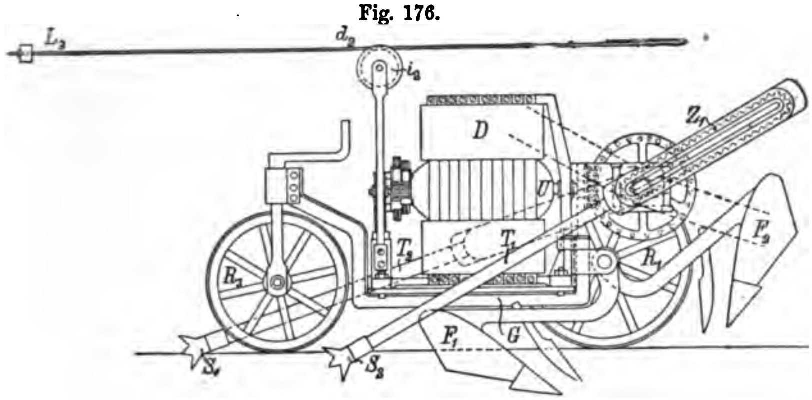
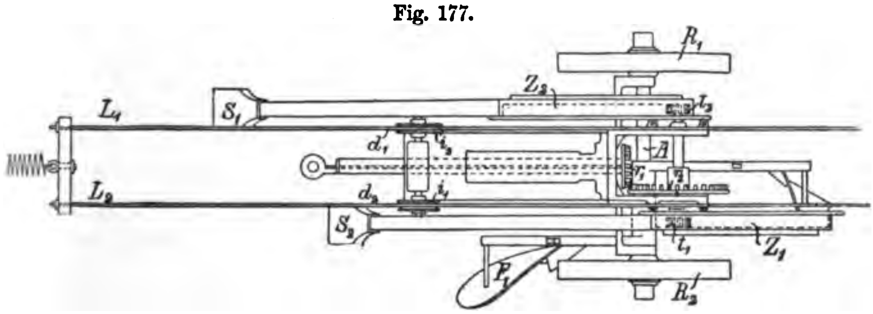


Fig. 177.



is brought from a primary dynamo-electric machine set in motion by any desired prime mover, by means of the conductors L_1, L_2, to a secondary dynamo machine fixed on the frame. The propulsion of the plough takes place by means of driving bars, T_1, T_2, which are provided with suitable metal shoes, S_1, S_2, which catch into the earth, and by properly adapted mechanism are pushed forward and drawn back, so that by this means a forward motion of the carriage is effected. The mechanism causing the oscillating

motion of the driving bars can be carried out in different ways by means of known arrangements. The inventor prefers in general the use of such mechanism, as is customary in English mangles, and such is shown in the figure. In this way the rotation of the armature U of the secondary dynamo effects by means of crown or tooth gearing through the wheels r_1, r_2, the rotation of the pinions t_1, t_2, which cause the pushing forward and driving back of the driving bars, T_1, T_2, by means of the toothed frames, Z_1, Z_2. These frames, Z_1, Z_2, are provided with an endless inside toothing, and have a nut running in it, in which the projecting axles of the pinion wheels, r_1, r_2, gear. By continuous rotation of the armature U of the dynamo electric machine D, the internally toothed frames, Z_1, Z_2, and with them the bars, T_1, T_2, are set in continuous forward and backward motion. The bars, T_1, T_2, thus strike against the earth, as the shoes, S_1, S_2, prevent too deep a penetration into the earth, a continuous or step by step forward motion of the vehicle occurs according as the wheels, t_1, t_2, are so set in the frames, that they drive forwards both driving bars at the same time or alternately. The plough share fixed to the frame G, or to the axle A, thus makes the furrow. Two plough shares, F_1, F_2, are fixed to the main axle, one of which comes into action when ploughing in one direction, the other in the subsequent propulsion of the plough in the other direction. For changing the direction of motion of the vehicle the toothed frames, Z_1, Z_2, with the bars, T_1, T_2, fixed to them are reversed. The distance of the plough shares from one another must depend on the depth of the furrows. Two or more plough shares can be placed near to one another when the conditions of the soil and of the power allow it.

In the plough represented in the figure two driving bars, T_1, T_2, are shown for driving forward, which are sufficient for light or ordinary soil and plain furrows; the number of driving bars can, however, without essential difficulty, be doubled or trebled.

Instead of the mechanism for the forward and backward motion of the driving bars T_1, T_2, which is described, winch or reversing mechanism can be used.

For carrying the current from the primary to the secondary machine, two rollers, i_1, i_2, are used, fixed to and insulated from

the frame G, which are always in conductive connection with the wire cords, d_1, d_2, stretched round them without tension. The insulated rollers, i_1, i_2, communicate with the terminals of the secondary dynamo machine, whilst the wire ropes, d_1, d_2, which insulated from one another are fixed at one end to the earth, at the other are connected with the terminals of the primary machine through suitable conductors. By this arrangement it is brought about, that with the continuous propulsion of the plough the conductive connection between the driving and driven dynamo machine is always maintained, whilst the vehicle during ploughing can make deviations. Instead of allowing both conducting wires, insulated from one another, to extend on the ground, the whole length of the furrows to be ploughed, and to run on the rollers placed on the plough, metal drums can be used, which are driven by springs or friction force, and from which the wire ropes unwind by the forward motion of the plough.

The touching of the ground by the conducting wires is harmless, and need not be prevented.

PATENT CLAIMS.

1. The propulsion of ploughs by secondary dynamos placed on them.

2. The shoving forward of the plough by driving bars, moving forwards and backwards with shoes suitable to the soil, which grip the earth.

3. The electrical connection of the primary and secondary machines by two slightly stretched wire lines or cords, either carried on contact rollers placed on the plough, or wound on the same.

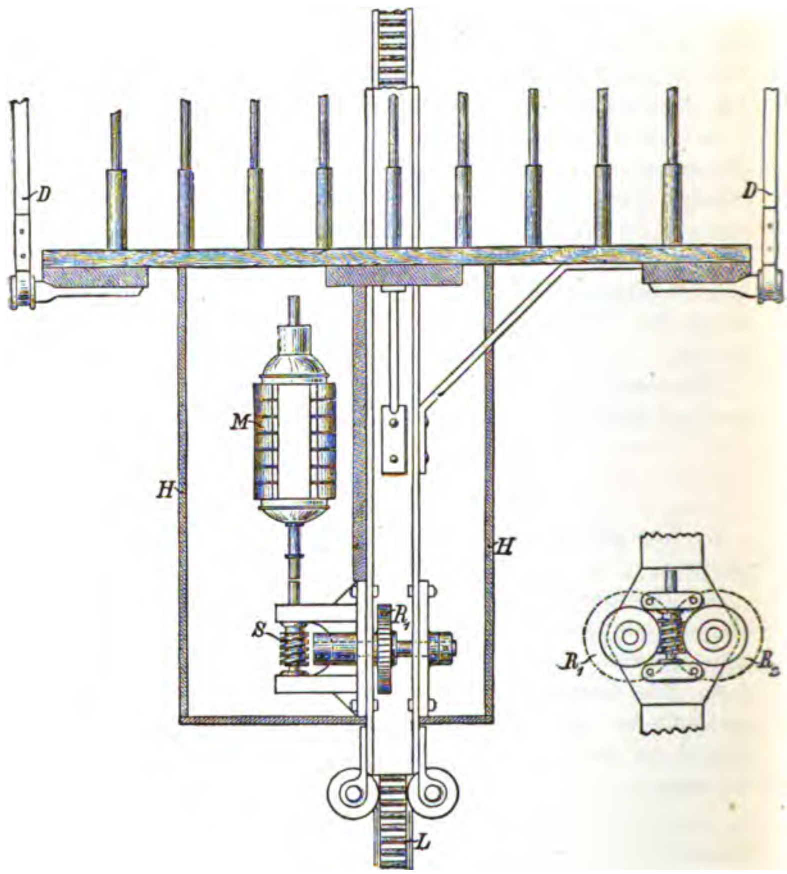
THE ELECTRIC LIFT.*

THE transmission of power by dynamo machines has found a new application in the lift for persons set up at Mannheim by the

* (Journal of the Electrotechnische Verein, October, 1880.)

firm of Siemens and Halske, which promises to be of considerable importance. Lifts for passengers, as now frequently arranged in large hotels and business places, to save the guests the time and

Fig. 178.



trouble of going up by the stairs, have hitherto almost without exception been arranged hydraulically. Rope lifts as used for raising goods, etc., are not considered safe enough for passenger lifts. The hydraulic lift is, however, very costly to instal, and commercially hardly practicable, as it necessitates the sinking of

a pressure cylinder of a depth equal to the greatest height of the lift desired. The working of such hydraulic lifts is also generally very expensive, as every separate lifting necessitates the filling of the pressure cylinder with water at a high pressure.

The electric lift will overcome the defects of the hydraulic lift, without being less safe than it. It depends on the transmission of power by means of dynamos. The small weight of such a machine in comparison with its driving power allows of the machine being placed on the lift to be moved, and of bringing to it by wire conductors the electric current producing the motion. The arrangement can therefore be run in such a way that the machine climbs up as it were by a fixed conductor or toothed rack and takes with it the cage fixed to it. This fixed conductor or toothed rack can be made of such strength that all danger of its fracture is removed. With very high lifts the toothed rack can often be fixed as desired to the walls of the building or shaft, so that it is not necessary to carry itself its whole length.

The first lift of this kind that was set up by Siemens and Halske in the Mannheim Industrial Exhibition, and which there served to carry up the public to a lookout tower, 20 metres high, is built on these principles. The toothed rack L (Fig. 178) is in this case a ladder formed of steel, the sides of which are of triple steel plates of 5mm. thickness and 60mm. breadth, which are so riveted together, that the full strength of at least two plates comes always into play in each of the two side pieces. Both sides are connected by means of riveted rings of round steel, 15mm. thick to a ladder-like toothed rack. The rings are at a distance of 35mm. measured from centre to centre. The ladder L reaches in a perpendicular position from the top of the lookout tower to the ground, and is firmly fixed above and below to strong beams.

The ladder passes through the middle of the cage, under which the dynamo M is placed, surrounded by a wooden casing closing it in. The axle of this dynamo terminates in an endless screw S, which turns the two toothed wheels R_1 and R_2, which on both sides gear in the rungs of the ladder. A lever on the cage is so connected with a current switch, that in the middle position of the lever the circuit is broken, whilst the positions of the lever to right or left bring it about, that the dynamo and with it the driving endless screw rotate in one or other direction, and

consequently move the cage up or down. By proper arrangements the switching over is performed automatically at each end point of the rise or fall.

The pitch of the driving screw is so small that the lift cannot run down when the current is interrupted. But nevertheless to save the work of raising the load of the cage and dynamo, and approximately to equalise the performance of the dynamo with the rise and fall of the cage, the cage and its mean load are balanced by a weight, which hangs from two wire band ropes D. The other end of the two wire ropes running over two rollers at the upper end of the observing tower is fixed to the cage. This wire rope and the toothed rack also simultaneously serve as conductors of the electricity, since they conductively connect together the primary and secondary dynamos. The ladder L is touched by two pairs of rollers brought above and below the cage, which carry off the current from the ladder L to the machine M.

By means of the electrical lift described in the few weeks of its use in the Mannheim Exhibition, about 8000 persons have been carried without accident up and down the observing tower. The velocity amounted to about 0·5 metre per second.

As advantages of this system over the hydraulic may be mentioned: 1, the comparatively cheap installation and easy erection: 2, the cheap working. This specially is of value, when a motor is already provided for driving the primary dynamo, or when several neighbouring lift proprietors unite in arranging for a common plant for working them.

For lifting goods, building materials, etc., in which absolute security is not a first necessity, as in the case of passenger lifts, the above described lifting arrangement would not be used except perhaps for lifting to very considerable heights, and instead of it lifting by ropes would be employed. It will, however, in many cases be preferable to employ electric transmission for turning the rope drums. Especially for building and other lifting arrangements for temporary use, electrical transmission of power appears very advantageous on account of the simplicity and ease of the arrangement and erection.

THE DYNAMO-ELECTRIC MACHINES.*

In a communication which was made to the Academy by my honoured teacher and friend, Martin Magnus, on January 17th, 1867, I denoted by the name "dynamo-electric machine," a machine system, in which the steel or permanently magnetized electro-magnets used up to that time in induction machines for the production of electric currents were replaced by electro-magnets, the wire windings of which form a portion of the circuit of the induced wire coils. I showed in this communication, that in every electro-magnetic motor turned by external force in the opposite direction to that in which it is moved by a galvanic battery inserted in its circuit, an uninterrupted increase of the current circulating in its windings must take place. I further showed that with a proper construction of the machine the magnetism remaining behind in the iron suffices, with sufficiently quick rotation, to bring about this cumulative process, so that a machine once rendered active acquires permanently the property of producing electric currents, the strength of which is a function of the velocity of rotation. Finally I also explained in this communication, that by means of this combination, the previously existing obstacle to the production of very strong currents by means of motive power is cleared away, and expressed the anticipation, that many departments of engineering would find a powerful incentive to further development, through the strong currents now at its command which could be easily and cheaply produced.

It required an interval of fourteen years before the last anticipation was actually realized. At present the metallurgical industry uses dynamo machines which daily precipitate tons of copper galvanically in a chemically pure condition, and thereby separate it from the precious metals which it contains. By the currents produced by dynamos, hundreds of thousands of electric lights are fed, and these already begin in many cases to supplant older methods of illumination. An almost illimitable range

* (Read at the Berlin Academy of Sciences, 18th November, 1880.)

however appears in recent times to have been won by the transmission and distribution of energy by dynamo-electric machines, and especially the conveyance of persons and loads by means of the electric current.

Although I have taken a share in this already active extension of the dynamo-electric machine, I have not considered it an occasion to acquaint the Academy with these labours, as they were rather technical than scientific problems, which had to be solved, to perfect the machine itself, and its accessories as regards its purpose for technical use.

Yet now that a certain progress has been made in this direction, I beg the Academy to allow me to lay before them in the first place a general view of the progress of this development and of the directions in which further improvements are to be pushed on, and in the next place to lay before you a work of Dr. Frölich, in which he has collected the experiments with dynamo-electric machines carried on by me and has developed a theory of their action and their application to the transmission of power.

In the original dynamo-electric machine constructed by me, the moving portion consisted of my rotating cylinder magnet, the construction of which I published in the year 1857.*

The alternating currents which arise in the conducting wires of this cylinder magnet owing to its rotation between the hollowed out poles of a strong electro-magnet, were sent in one direction by means of a commutator with sliding springs, and then traversed the windings of the fixed electro-magnet. With this machine the unexpected circumstance arose, that the heating of the rotating armature was much greater than calculation gave, when the resistance of the surrounding wire and the strength of current were alone taken into account. As the cause of this great production of heat, it was soon seen that the iron of the armature itself heated considerably. This heating was partly to be ascribed to the currents, which the magnetism of the fixed magnet must produce in the iron of the rotating armature (so called Foucault currents), but it was still found to continue to a great extent, when the armature was made of thin iron plates with insulating pieces inserted which stopped the Foucault currents. Another

* Poggendorff's Annalen, Vol. 101, p. 271.

cause of the production of heat in the iron must therefore have been active. A closer consideration of the phenomenon proved in fact that the iron became heated by very quick and sudden alterations of its magnetic polarity if the magnetization approached the maximum of the magnetic capacity of the iron. This inconvenience of the heating of the rotating armature made it necessary to cool it with a current of water when the machine was in continuous use, in order to prevent the scorching of the covering of the wires, and of the other parts which might be injured by heat. The inconvenience of this cooling and the considerable loss of energy caused by the transformation of work into heat nevertheless presented a great obstacle to the application of the dynamo-electric machine. Its removal was partly effected by the magneto-electric current generator which Pacinotti described in the Nuovo Cimento in 1863. This consisted of an iron ring, which was wound throughout its whole length with a wire coil, and which rotated between the hollowed-out poles of a permanent magnet. By magnetic induction magnet poles were formed in this iron ring, which were opposite to the opposite poles of the fixed magnet, and retained their position while the iron ring rotated. As in this way the outer portion of the wire windings of the ring continually traversed the two fixed magnetic fields between the magnetic poles and the iron ring, oppositely directed electro motive forces must arise in the closed surrounding wire, which could produce no current as they were equally strong. But if the separate wire windings, or the equally spaced groups of windings were joined up to metal pieces, which were grouped concentrically around the axle of rotation of the ring, and these were allowed to move under two fixed sliding springs, standing opposite to one another at the same distance from both magnet poles, the two opposite currents of the wire windings united, and were now diverted, into a single continuous current through the conductor connecting the sliding springs. I had already much earlier used a similar combination, in order to produce continuous currents with the assistance of an induction coil closed on itself,* but the Pacinotti ring has

* A machine of this kind for the production of continuous currents of high tension for telegraphic purposes was exhibited by Siemens and Halske in the London Exhibition of 1855, and is now preserved in the Post Office Museum

the advantage over this of greater simplicity and that the regularly occurring change of polarity produces little heat in iron.

It would appear that Pacinotti used his ring machine only in the construction of small magneto-electric current generators and of small electro-magnetic machines. Gramme in Paris first in the year 1868 had the happy idea of making dynamo-electric machines with the help of the Pacinotti ring and thus to get rid of the troublesome heating of the iron of the rotating cylinder magnet.

The Gramme dynamo-electric machine has however the imperfection that only the outer portions of the wire windings traversing the magnetic field are subjected to inductive action, whilst their inner halves remain inactive and only uselessly increase the resistance of the circuit. v. Hefner Alteneck got over this to a great extent by means of the dynamo-electric machine called after him, by covering the rotating ring or a massive iron cylinder with windings on the outside only, which communicated in groups as in the Gramme machine with contact pieces and sliding springs or wire brushes. The Gramme and Hefner machines have been frequently described and discussed in scientific and technical writings, and I shall therefore not enter here into a special description of them. They constitute at present the typical forms of machines for the production of powerful electric currents for technical purposes and have on this account been made of the most various forms and sizes. Thus the machines v. Hefner's construction which have been used

of this town. It consists of a flat cone or plate which rolls upon a level surface. If the top rim of the cone was provided with small electro-magnets, the windings of which formed a closed circuit, whilst the flat surface was provided with steel magnets, by the rolling of the plate the half of the electro-magnets approached the poles of the steel magnet, whilst the other half removed from it. The common winding wire communicated between each of the two horse-shoe magnets which were in radial position, with contact pieces which were brought into the circle around the axle, which turned the plate, *i.e.*, allowed it to roll. Two insulated sliding springs connected with the axle were so arranged that they always touched the contact-places which led to the electro-magnet nearest to and furthest from the steel magnet. As on the approach and removal of the electro-magnets from the permanent magnets, currents of opposite direction were induced in the windings of the former, these united in the sliding springs with uniform rotation into a continuous constant current. If the machine were to be employed as an electro-magnetic motor an iron core would be used and the electro-magnets set in the level plane. See also at p. 97, and following, of this collection the paper on the plate machine.

for refining copper in the copper works at Oker, and each of which daily dissolved about 300 kilogrammes of black copper in twelve cells placed in series, and again galvanically precipitated it in the shape of plates, have winding wires of 13 square centimetres section, whilst machines for the production of many electric lights and for the transmission of power are wound with wires weighing many hundred weight.

These outputs and dimensions, colossal in comparison with former electric apparatus, will however be still farther increased if the contemplated use of the dynamo-electric machine for the transmission of power is universally carried out.

When two dynamo-electric machines are brought into the same circuit, and the one revolves at constant velocity, the other must revolve as an electro-magnetic machine in the opposite direction as follows at once from the consideration that a dynamo-electric machine is an electro-magnetic one turned in the opposite direction. The opposing current which this machine rotated by the current produces now weakens the current produced by the primary dynamo-electric machine, and thus diminishes at the same time the work required for the rotation of the latter. If the secondary machine had neither internal nor external work to perform its velocity would increase until its opposing electromotive force balanced that of the primary machine. Then no more current would pass through the conductor, and work would be neither consumed nor produced. This condition of equilibrium can naturally never be completely attained because the secondary machine has to overcome internal resistance, and because the primary machine must attain a velocity dependent on its construction, before the dynamo-electric strengthening process of the current begins. If the secondary machine has to perform work, its velocity thereby diminishes. With this diminishes the opposing force dependent on the velocity of rotation, and a current now traverses both machines corresponding to the difference of their electric forces, the production of which requires force, and which on its side performs the work imposed on it in the secondary machine. I have already in other places* referred to this, that the useful effect obtained by this

* Journal of the Electrotechnische Verein, February Number, 1879.

transmission of power has no constant amount, but depends on the ratio of velocity of both machines and that it increases with their velocity of rotation. By the research given below this has been confirmed within certain limits. Hitherto a useful effect of 60 per cent. of the work expended has been practically attained, and with the largest machines that could be used which certainly were not specially constructed for the transmission of power but for lighting purposes. 10H.P. as measured by the Prony brake have been transmitted with a useful effect on the average of 50 per cent. It hence follows that with electric transmission of power only half of the work expended is regained, whilst half is used up in overcoming resistance in the windings of the machine and in the conductors and is transformed into heat. The amount of this loss of energy is evidently dependent on the construction of the machine. If there were no prospect of effecting an essential reduction of the same, by improvements in construction, the technical application of electric transmission of power would continue somewhat limited. It is therefore of importance to determine the causes of the loss of energy lying in the construction of machines and then to take into consideration, whether and in what way a complete or partial removal of this source of loss is to be arrived at. The purely mechanical losses of power through friction, air resistance, shocks in the machines may be left out of consideration. They form only a small part of the loss and their reduction to a minimum may be effected by the use of known principles of construction.

The essential physical cause of the loss of energy and one not altogether to be removed, is the heating of the conductor by the electric current. As with the machines, in which no sudden alternation in the magnetism takes place, no immediately perceptible heating of the iron of the electro-magnets occurs, only this heating of the conductor by the currents traversing it needs to be specially taken into consideration. These conductors are here not only the conducting wires of the machines, and their conductive connections, but also the moving metal masses of the machines, in which currents are induced, which heat them (the so-called Foucault currents). There follow hence as the essential bases for the construction of dynamo electric machines :

1. That all unessential resistances of the machine, *i.e.*, here all

those conducting wires which do not work electromotively, should be removed as far as possible or diminished.

2. That the conductivity of all conductors, also those acting electromotively, be made as great as possible.

3. That by the arrangement of the metal masses, in which Foucault currents can be produced by moving conductors or magnets, the path for the current should be cut up as much as possible.

4. That the magnetism produced in the electro-magnets should come into action as completely and directly as possible.

5. That the divisions of the windings of the induced wire, which are traversed by currents of alternating direction, should be as small as possible, so that the extra current arising from the change of current be as small as possible.

If we consider the two systems of machines which we are now discussing, that of Gramme and von Hefner, from the standpoint of these conditions of construction, we shall find that these are carried out in both in only an incomplete manner.

In neither machine does the magnetism act inductively directly on the moving wires of the armature, but this takes place principally indirectly through the magnetism excited by the hollowed-out magnet pole of the fixed magnet in the Gramme ring or v. Hefner's externally wound iron cylinder. That the direct inductive action of the hollowed-out magnet pole on the rotating wires is only small, is proved by experiment, if the iron cylinder of v. Hefner's machine is replaced by a cylinder of non-magnetic material. But this also follows at once from the consideration that only those portions of the hollowed-out magnet pole act inductively on a moving wire, in the same sense as the magnetism of the inner cylinder, which lie outside the plane laid through the rotating wire parallel to the axis of rotation and perpendicular to the radius of rotation of the wire, whilst the portions of the hollowed-out pole lying within this plane exert an opposing action. Therefore, in order to produce a determined inductive action, a much stronger electro-magnet would have to be used in both machines than would be necessary under more favourable circumstances. To produce this more powerful magnetism, a greater portion of the conducting wire used

in the machine, must be applied to the magnetization of the fixed magnet at the cost of the length of the induced wire.

In order to obviate Foucault currents in the rotating iron ring, the latter is wound both in the Gramme and v. Hefner machines with covered or varnished iron wires. The circuit of these currents is in this way confined to the surface of the iron wires, and consequently the loss of heat through them made very small. On the other hand, the hollowed-out magnet poles still present to these currents large closed current paths which necessitate heat losses.

A great loss of energy takes place in the Pacinotti ring of the Gramme machine as already stated—by useless lengthening of the winding wire—by the circumstance, that only the outer portions of the winding wire act electromotively, whilst the portions of it lying inside the ring only act as conductors and must be uselessly heated. With von Hefner's iron cylinder wound only externally, this circumstance is decidedly more favourable, yet even in this useless resistances are introduced by the pieces of wire covering the ends of the cylinder. If the length of the cylinder is, as is usually the case, many times the diameter, then the loss of conductivity through the wires not acting inductively is always much less than in the Gramme machine. On the other hand, however, this has the advantage of a simpler winding, which renders possible the introduction of a greater number of smaller winding sections, whereby the loss of energy through the extra current brought about by changing the direction of the current, and the troublesome sparking partly dependent on it, is diminished.

Of yet greater importance than these sources of loss, which all lead to useless increase in size of the machine necessary for the production of a definite effect and its conductive resistance, is, however, as follows from the comparison of our experiments by Dr. Frölich, the reactive influence of the induced current itself traversing the wires of the machine. This influence is a double one in both the machines here considered, namely, in the first place, the shifting of the position of the magnetic poles of the Pacinotti ring or of the v. Hefner cylinder, and secondly, the lowering of the magnetic maximum both of the fixed magnet pole and ring by magnetization of the iron in the direction

of the induced current, consequently at right angles to the direction of the effective magnetism. The induced currents seek so to magnetize the ring or the cylinder, that the plane of the poles is perpendicular to the plane of the poles of the fixed magnet, the actual polar plane must therefore be the resultant of both magnetic influences standing at right angles to one another. This also follows from the fact that in order to obtain the maximum of work, the sliding springs when the machine is at work must be shifted to an amount dependent on the strength of the inducing current. Through this magnetization in a direction perpendicular to the direction of the induced magnetism, a portion of the hypothetical magnetic iron molecules are influenced; therefore the magnetization of the ring by the fixed magnet must be correspondingly smaller. From the circumstance that with quicker rotation of the cylinder the contact springs or brushes must be placed further back than with a slower rotation, even when the strength of the current is maintained constant by the insertion of external resistances, it further follows that either a carrying along of the magnetism generated in the ring or cylinder through the fixed magnet poles of the rotating iron occurs, or that time is necessary for performing the magnetization, the ring magnetism is consequently smaller, the greater the velocity of rotation of the ring.

To these circumstances is also to be ascribed the remarkable phenomenon, that the current strength of short circuited dynamos after the close of the rising process is nearly proportional to the velocity of rotation, whilst the dynamo electric principle in itself (*i.e.*, without reference to the heating of the wires, the secondary action of induced currents, etc.) necessitates with every velocity of rotation a rise of current up to the same limitless height if the magnetism is proportional to the strength of current.

Whether and how far a perfecting of the construction of the dynamo-electric machine will be able to obviate the deficiencies described cannot be determined theoretically. To enter here on the plans proposed for such improvements would be aimless. Nevertheless, to complete the picture of the actual position of affairs, I will now describe some of my experimental constructions, which form the point of departure for these endeavours. The direct

object of them was to construct machines for chemical purposes, in which a very small E. M. F. is sufficient, but a very small internal resistance is necessary.

One of these experimental constructions, the so-called pot machine, is based on my cylinder magnet or double T armature, already described (Siemens' armature). When such a transversely wound magnet, the polar surfaces of which form part of the cylinder, is surrounded by parallel conductors, which at one end are connected conductively together, and are allowed to rotate around the cylinder magnet, positive currents are induced in those wires directly above one polar surface and negative currents in the other, which, owing to the resistance of the machine being exceedingly small, unite in currents of great strength through properly arranged sliding contacts, which connect all the induced wires or copper pieces in the same direction conductively together.

The potential difference of both sliding contacts on account of the shortness of the induced conductor can necessarily be but small. With the greatest permissible velocity of rotation, it does not even attain to one Daniell; but this is sufficient for galvano-plastic purposes.

By the application of a covering of insulated iron wires, the strength of the magnetic field, and with it the electro-motive force of the current can be considerably increased. With this construction of dynamo-electric machine the magnetism acts directly inductively; there are therefore wanting in it a number of the faults of construction above discussed. It therefore forms the point of departure for improved constructions of dynamo machines, about which I reserve further communication for a future occasion.

A second construction depends upon quite a different principle, namely, on so-called unipolar induction. As is known, there exists in a hollow cylinder, which is allowed to rotate around the north or south pole of a magnet, a current impulse which manifests itself as a current in the conductive connection of sliding springs at both ends of the rotating cylinder. A horse-shoe, with long cylindrical legs, was so placed that the poles were directed upwards. The lower third portion of the leg was surrounded with wire windings of very large diameter (about 20 sq. cm.). Around the upper two-thirds of the length of the

legs rotate two hollow cylinders of copper, the lower ends of which communicate by a system of sliding springs with the upper ends of the spirals connected to each other, whilst the sliding springs are insulated at their upper ends. The rotating cylinders were surrounded with an iron screen, the object of which was to increase the magnetism of the electro-magnets or the strength of the cylindrical magnetic field, in which the copper cylinders worked. With the very considerable dimensions of this machine, a current was produced by unipolar induction, which circulated in a very small resistance, and had an E. M. F. of about one Daniell. Notwithstanding this comparatively considerable output the useful effect of this machine was not satisfactory, for the friction of the sliding pins was too great, and the output did not correspond to the size of the machine.

I will here only remark that my friend, G. Kirchhoff, made me an important proposal, to increase the E. M. F. of this machine by increasing the length of the induced conductor.

He proposed to separate the walls of the rotating hollow cylinder by longitudinal cuts, and then to combine them again to a hollow cylinder with insulating distant pieces. Each end of the insulated rod thus formed was to be conductively connected with an insulating sliding ring. Through the sliding springs arranged in the circuit, the ends of the rods of both cylinders could be so connected that they worked electromotively in the same sense. Technical difficulties have hitherto prevented the carrying out of this important proposal; it is not, however, improbable that these can be overcome. It is remarkable that with this machine the magnetism of the great horse-shoe magnet falls off much sooner from proportionality to the primary current than was to be expected. In the following table, the first column contains the strengths of the magnetizing current in units of current; the second, the difference of potential at the sliding springs in Daniells; the third, the number of revolutions of the copper cylinder. If the magnetism were proportional to the strength of the primary current, the numbers in the fourth column would be proportional to those in the first, which is evidently not the case. With the circuit closed through a resistance, the strength of current given in the last column is just as little proportional to the product of the current strength

of the primary circuit into the number of revolutions divided by the inserted resistance.

TABLE.

UNIPOLAR MACHINE.

Primary Current in $\frac{\text{Dan.}}{\text{S. U.}}$	S, Tension at poles in Dan.	v, Revolutions . $\frac{S}{v}$ 100	External resistance in $\frac{\text{S. U.}}{\text{Mill.}}$	Current strength in $\frac{\text{Dan.}}{\text{S. U.}}$

It cannot be assumed that the magnet legs, which consisted of iron tubes of 16 cm. external, 9 cm. internal diameter, and 116 cm. length, were already magnetized to the maximum because the weak remanent magnetism already gave an eighth of the strongest tensions as follows from the 10th row of experiments. But it is possible that the magnetism is not equally divided on the periphery of the fixed magnet leg, and that therefore the part of the rotating cylinder, which was passing at each moment through the weaker magnetic fields, formed a shunt for the currents induced in the stronger fields. By carrying out Kirchhoff's proposal this would be avoided.

ELECTRICITY AS AN AID AGAINST DANGER BY FIRE.*

GENTLEMEN,—The terrible disaster in Vienna has set the whole world in agitation, and competent and incompetent people of all classes propose methods to avoid such catastrophes in future. I think therefore that the Electro-technical Society also cannot pass over in silence this terrible occurrence, and that it is proper to consider more closely the question what influence electrical science can exert to reduce the danger of fire in general and to avert such catastrophes. I have promised to give an introductory address to this discussion, but I beg you not to

* (Address to the Electrotechnische Verein, 27th December, 1881.)

consider the title "Electricity as an aid against danger by fire" under which I have announced my address, as though I wished to put forward electricity as a universal means for removing danger by fire. This is altogether impossible. The danger of fire cannot be removed. When we consider that we live in combustible houses, in which most of the objects that surround us, the furniture, chattels, hangings, curtains, and beds, as well as our clothing, especially that of women and children, are combustible, that we are always using fire in these combustible surroundings, that we heat with coal or wood, that we light with gas, oil or candles, using easily inflammable matches for the purpose, and so often carry them in our pockets, it is certain that it is absolutely impossible, to get rid of the danger of fire itself, or even considerably to reduce it.

This danger has continually and considerably increased although houses are now more and more built of stone and iron, stone stairs are used, thatched roofs done away with, and other means brought into use for its diminution.

If, nevertheless, the number of fires, and damage caused by fire on the whole do not increase, but are rather diminished as statistics show, this is in general to be ascribed to the greater experience mankind has attained in its continual fight against fire. We are born to a standing fight against fire. Children from their very infancy are drilled by their mothers to be cautious with fire, to put out small fire dangers, and we all form an ever watchful fire brigade.

With increasing intelligence and culture our aids in this continual fight are improved. There are many arrangements for checking the outbreak and the extension of conflagrations. These arrangements will form in the first place the object of our consideration.

The fact of the danger of fire existing everywhere, and always, has taught us, that it is essential to put out small fires quickly before they have had time to develop danger. It is therefore important to have everywhere at hand good means of extinguishing and also to have ready at the right time well drilled and organized quenching forces, to put out any conflagration that has broken out, before it has become dangerous. Electrical science has already for some time past played a considerable

part herein. In our town of Berlin we had already, in 1852, arranged systematically a well-organized fire brigade and a network of fire telegraphs comprehending the whole town, and it is quite certain that since that time, the large dangerous fires in Berlin have been proportionately very much reduced. This fire telegraph consists in suitable arrangements for bringing each fire that arises to the knowledge of the fire brigade as quickly as possible whilst everybody remains at liberty to extinguish the fire by his efforts until the firemen arrive. A system of fire brigade stations and depots is uniformly distributed throughout the town, and these are connected by telegraph lines with each other, with the central station of the fire brigade, and with the police station. The arrangements are so made, that from any one station all others can be simultaneously alarmed, and at the same time receive information of the place of the fire. With this telegraph network a second network of conductors extending further is arranged, in which so called fire alarms are introduced. These are simple mechanisms, which can be set in action by anyone through a spring or pull, and which then automatically give the alarm to the nearest fire station, and at the same time announce the number of the alarm post. Thence the information goes out to all the other stations of the town. This arrangement has proved to be very beneficial and has been copied in almost all great towns. It can be further developed with advantage by the number of alarm posts being still further increased. If in Vienna, as it is reported, one such alarm post which existed in the theatre was no longer accessible after the outbreak of the fire, and thus the alarm was omitted, the catastrophe would probably have been considerably diminished if not altogether prevented, had more fire alarms been in existence. All large and specially combustible buildings such as factories, public buildings, etc. should in particular be in direct communication with the fire brigade stations by one or more alarm apparatus, so that the announcement of an alarm of fire may come as quickly as possible to the right station. This is necessary not alone from a onesided but a universal point of view, because, especially in narrowly built streets, the outbreak of a great fire may give rise to the question of the existence of a whole district, or as the Hamburg conflagration proves of a whole quarter of a town.

This further extension of the telegraphic alarm system is to be recognized as the most important means, by which electrical science can work for the diminution of losses by fire. But this system can be still further extended. In large factories, theatres, public buildings, there are so many places exposed to fire, far removed from one another, and often difficult of access, that the simple alarm "it burns" is not sufficient for such a complex building. At the same time the spot where it burns must be given, as often some minutes are decisive in averting a considerable loss. For this purpose we have in our own factory a special arrangement, which works so that the fire alarm is united with the watchman's control.

In a wire conductor which runs throughout the whole factory apparatus are inserted at all dangerous places, and those difficult of access, which serve both purposes at the same time.

The watchman must then in traversing the factory, pull a special knob which is somewhat concealed, by which the time of their arrival at the place is registered on a paper strip in the office. This also has the great advantage that the apparatus itself is always kept in working order. For a mechanism, which is not regularly used or controlled is not to be depended on. To the same apparatus, there is attached a second easily recognizable knob by which anyone who draws it can give a fire alarm, whilst an alarm bell is set in action, and at the same time the number of the warning apparatus is exposed to view.

It is thus made known in what room there is danger of fire, and then all the available forces can be directly applied to remove the danger.

If in all great buildings specially liable to fire, such as theatres, factories, etc. such arrangements are contrived connected up to the fire telegraph, it would be wonderful if a fire were not as a rule stopped, before it had attained dangerous dimensions, when a well-organized troop, such as our fire brigade, is at hand.

Another sphere of action of electro-technical science against the danger of fires lies in electric transmission of power. In this direction recently many projects have come to the fore through the Vienna catastrophe. Most inventors wish to effect both the fire alarm and the extinguishing automatically. They would have

combustible cords stretched, which should be destroyed by means of the fire, or would bring about contacts by means of the heat of the fire, in short by means of the fire itself, something should become active, which should itself give the fire alarm, drop the iron curtain at theatres, set water jets going, open ventilators, etc. I must declare in general against such automatic arrangements. The dangers of fire are so manifold, and manysided, that dependence could not be placed on such arrangements, even if they were always in good order. It makes its appearance as a rule where least expected, and when it has reached the automatically working arrangements and has set in motion the necessary action it is too late to put it out. The only safe aid against the danger of fire which is always in proper working order, is the energetic sensible man ; he must have the means of bringing his energy into action, at the right moment, at the right place, and must have the proper extinguishing means quickly at hand. In this, electric transmission of power can be used with advantage. Arrangements can easily be made, to effect with great speed mechanical operations from one or more points by simple contact keys, by which the fire can be confined or its further extension be checked, or it can even be extinguished. This is especially desirable in theatres, in which a large closely packed number of persons are placed in an unusually great danger of fire. If electric lighting is used, or other electric transmissions of power are permanently arranged for the carrying on of necessary work such as the shifting of scenes, moving of heavy curtains, or drops, etc. the necessary current is always at hand for the application of the transmission of power. If the iron curtain of the Vienna Theatre had always been operated by electric transmission of power, the heat of the fire which had broken out would not have prevented its fall, as must have been the case. The electric machine endures a considerable amount of heat, and would not be stopped by it from exerting its action, like the man in charge of it.

But electricity does not only contribute in a very effective manner, for the quick removal of existing danger of fire, it can also diminish the danger of fire to a great degree by the use of electric lighting.

Many opposite views set forth in public papers, in recent times

are remarkable. The electric light is dangerous to life and in so high a degree dangerous on account of fire, that even insurance companies have hesitated to insure electrically lighted dwellings at the usual rate ! !

If however the electrical engineer is disposed to allow such untenable statements to pass unnoticed it will yet be judicious to test the basis on which they rest. They pass from one paper to another, and are at last regarded by the public as true. Electric lighting naturally gives rise to risks from fire, and it can also be dangerous to life under certain circumstances by unreasonable use. It may also be conceded that these dangers are considerably increased, owing to the novelty of the thing, and the small extent of the knowledge of the science of electricity, as also through want of experience. But it may be asked in the first place, whether the danger, which has appeared in isolated cases, is based in the nature of things, and secondly whether it is greater or smaller than in the other kinds of illumination. As a cause of danger from fire, certain cases are cited where fire risk has arisen through the falling down of burning pieces of carbon. In another case thin wires, which led to incandescence lamps, have become loosened and come into contact. They have thus become red hot, and have kindled neighbouring inflammable objects. In a third case, electric sparks have arisen from uncovered leading wires, and have kindled neighbouring wood. Concerning the first point, formerly when pieces of carbon cut off from retort coke were used, it frequently happened of course, that glowing pieces of carbon split off and fell. With the pressed carbons now universally used, this danger is however completely got rid of. Nevertheless no competent person would place electric lamps in rooms where there was risk of fire without a secure covering of glass with wire netting, or of closed lanterns. That thin leading wires which are traversed by strong currents, become red hot is a known fact. It is the duty of the electrical engineer so to determine the conductivity of wires, that a dangerous heating of them cannot arise, and to fix and cover them so securely that a loosening is impossible. Such a case may indeed for once arise in a temporary installation, like that in the Paris Exhibition palace, but it is not then electricity, but the ignorance and indiscretion of the workman, and of the engineer conducting

the work, which is guilty of the disaster. The third case is quite incomprehensible, that sparks have arisen from uncovered conducting wires, that nails have been made red hot, and the wood in which they stuck set fire to. The electric currents used for electric lighting have a relatively low electric pressure. As a rule it does not exceed that of a galvanic battery of 100 Daniell cells, or volts. Such an electric pressure has no measurable striking distance. Even with pressure of a thousand volts, no spark passes over between the conducting wires or from them to other bodies without previous metallic contact. The often repeated statement, that sparks of lightning-like flashes had passed from the conductors, can therefore only rest on self-delusion. A conducting wire fixed to wood, can certainly become red hot and set fire to the wood, if it is too thin in proportion to the current which traverses it, or if it consists of not sufficiently well conducting material. But then again it is not electricity but the bad workmanship that is at fault. Well-arranged electric lighting does not offer all these dangers, and must be considered completetely dangerless.

The dangers to life and health through electric machines and conductors are equally exaggerated. With very high tension electric currents, as they have been lately carried out by Brush in America it can indeed be dangerous to life, if one simultaneously touches both terminals of the electric machines, or the conducting wires, as the powerful current traversing the body produces a muscular contraction, which makes it impossible to leave hold again quickly. In order to avert this, the conductors must be protected against accidental touching. If anyone does it intentionally, as was the case in an instance cited with a Brush machine, he runs wilfully into danger, as if he placed his hand under the driving belts of a machine. That the danger is not exceedingly great, may be gathered from the circumstance, that in the factory of Siemens and Halske, in which more than anywhere else in the world, strong electric currents are experimented with, no one has been injured by the electric current.

But if electric lighting is not always quite free from fire risks, yet it can certainly not be at all brought into comparison with the fire risk of any other kind of illumination and especially gas lighting. With this there is specially the danger of explosion,

which has happened everywhere, where unburnt gas has mixed with air, which so much increases fire risk. Further the lighting of gas flames in spaces which are filled with easily combustible materials, as in theatres, is always attended with considerable risk of fire, a danger which is equally prevented by electric lighting, as the danger of explosion, and that of poisoning by outstreaming unburnt gas.

Against the application of electricity to the lighting of theatres, the consideration has hitherto been opposed not without reason, that illumination by means of strong electric lights disturbs the artistic effect aimed at, as the shadows are so strong and unequal, and the blue light is unsuitable. For the greater part these not unfounded opinions have been removed by the division of the electric light first accomplished by the firm of Siemens and Halske. By means of the differential lamps, which are at present everywhere brought into use, in forms only unessentially different, the light passes out from one source of electricity, can now within wide limits be divided in space, and ugly shadows thus prevented. That the electric light is bluish, is an error which depends on self-illusion, as I have already shown in another place. By direct comparison of the colour of sunlight with that of electric light it is proved without doubt, that an electrically illuminated white object compared with one illuminated by sunlight appears yellow, whilst illuminated by gas light it appears red. The self deception only exists in that we are accustomed to see the world lighted red after sunset, and that from this basis we form a different scale of colour. Daylight would then at night also appear blue to us, like yellow electric light. This false impression would be overcome if electric light were universally applied. But as this is not yet the case nor will be for some time, and as the collection of colours of stage decorations, of the toilets and make up of the players have been arranged in the first place for illumination by red gas or lamp light, the objection to stage illumination by electric light must be acknowledged as well founded. Progressive electrical science has however already found assistance in the improvement of the incandescence electric light. The incandescence light in contradistinction to the electric arc is really the oldest manner of producing light by the electric current. Already Volta, the great discoverer of the electric current and of the battery called

after him, found that wires glowed brightly, when they were traversed by powerful electric currents. Subsequently it has been frequently tried, to utilize this phenomenon for the purposes of illumination. Grove the celebrated discoverer of the battery named after him had already busied himself with the practical realization of the incandescence light, and brought into use for the purpose both platinum wires and plates of carbon. There is besides the incandescence lamp of Mr. King to be mentioned, who caused pieces of carbon to glow in the Toricellian vacuum. Finally later Jobard, de Changy, and especially Lodyguine in St. Petersburg have busied themselves with the incandescence light. By Edison, Swan, Maxim, and others these incandescence lamps have recently by degrees been further improved by better construction of the carbon filaments and perfection of the vacuous space, in which they are brought to the glow. It has hence been possible to produce incandescence lamps, which have the illuminating power of strong gas flame, and can burn for months without the delicate carbon filaments being wasted or broken. The energy which must be consumed for the production of such incandescence lights is indeed always considerably greater than for electric arcs, one can however extend by their means the division of the electric light up to any desired limit. For the purpose of theatre lighting especially the incandescent carbon lights have the special advantages, that with them the danger of fire is almost entirely removed, that they are exceedingly easy to light, to extinguish and to modify in strength, and that the colour of the light is reddish like that of gas. Even in the case of the breaking of such incandescence lamps there is no fire risk, for the little thread of carbon then breaks, and becomes black almost immediately. It could not even set fire to touchwood surroundiug it.

By a combination of true electric lighting by means of differential lamps with incandescence lamps the problem of dangerless illumination of theatres can be solved in an almost perfect manner. If the curtain is down, a bright vivifying light should illuminate the auditorium. This can be attained almost in a moment by a correspondiug number of properly placed differential lamps, and also this bright illumination can be removed in a moment before the raising of the curtain. Then the auditorium will be lighted with a mild, and like the stage with a

reddish light. For this purpose one has only to place one or more circles of incandescence lamps in the gallery, which remain continually in action. In the same way the corridors and staircases can be lighted. In order that in case of the failure of a machine, or the breaking of a wire darkness may not occur, one will have had the foresight to arrange two quite different circuits with separate machines, and to connect the incandescence lamps alternately to one or other circuit. In very large buildings three or even more circuits could be arranged, whereby the safety of the illumination would be almost absolute. It is, however, specially important to banish gas, as liable to occasion fire, as well as all flame lighting from the stage. For this purpose there can hardly be more suitable illumination than the electric incandescence light. Incandescence lamps can be arranged, lighted and extinguished everywhere with great ease, after the conductors are once securely and firmly placed, and every lamp for itself or in series from one place, the strength and colour of the light can be increased or diminished at will from dark red up to the reddish white light of the best gas light, and this illumination is so absolutely without danger, that the hermetically closed little lamps, only broken with difficulty, can be brought into direct contact with the most combustible material.

All these circumstances make electric lighting so specially suitable for theatre lighting, that it now only appears to be a question of time for a theatre to be seen without it. To shorten this time as far as possible, it is much to be wished that electrotechnic knowledge had a greater extension. At all technical schools, at least at all the technical high schools, chairs of electrical engineering should be founded, in order to make at least our technical youth better acquainted with the science of electricity and its technical application. With increasing knowledge the now prevailing fear with reference to the application of electric light would be diminished, and a number of universally extended prejudices against it would be removed.

As incandescence electric lamps have not been hitherto brought before this society, I have made a collection of the best known and best forms of them, and will set them in action before you one after another.

The first is the incandescence lamp of Changy in Paris, whose

experiments with incandescence lamps Jobard already mentioned about twenty years ago. The carbon consists of carbonized blades of a kind of grass. The second is the well known Swan incandescence lamp, the third the Edison. Both of these are carbonized plant fibres.

The others have come from our factory (Siemens and Halske). They differ from each other in that the incandescent carbon does not consist of natural plant fibre, but of pressed coke or graphite rods. This method has the great advantage, that the conductive resistance of such long pieces of carbon is always the same, so that all the lights are equally bright, without necessitating any special regulation.

As the time is so far advanced I will not on this occasion enter into the theory of incandescence lamps, but I will reserve this for a future meeting.

IMPROVEMENTS IN DYNAMO-ELECTRIC AND ELECTRO-DYNAMIC MACHINES.*

The rotary dynamo-electric machine shewn in Figs. 179 and 180, which also serves as an electro-dynamic machine, when the position of the commutator is altered, differs from all dynamo-electric machines hitherto known, principally in that in it, in the same way as in the oscillating electro-dynamic machine of Page, the same coils of wire in which the current is induced also excite the effective magnetism.

An iron sheet a is bent into an open cylinder. The missing piece a^1, can be filled up with brass, or other non-magnetic metal. At one end of the hollow cylinder thus formed, is fixed a toothed wheel c of the same thickness as the wall of the cylinder. The cylinder rotates between the six friction rollers $d\,d\,d$ and $d_1 d_1 d_1$, of which the first three are connected with pinions $e\,e\,e$, which gear with the toothed wheel of the cylinder. At the end of the axles

* (German Patent, No. 19779, of 2nd February, 1882.)

fff on which are fixed the friction rollers and the drivers, there are three similar pinions *g g g*, which gear in the toothed wheel *h*,

Fig. 179.

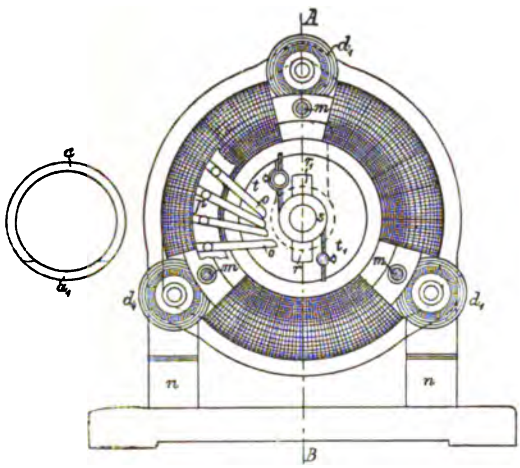
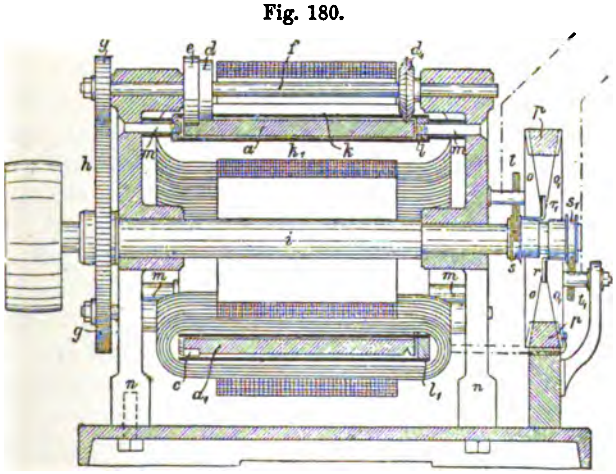


Fig. 180.



placed on the main axle *i*, which runs through the whole machine. This axle and the cylinder must therefore rotate uniformly. The rotating cylinder is surrounded by the brass

plate cylinder k and k_1, which, after the cylinder is fitted with its driving wheel into the ring-shaped intervening space, which they together form, is covered in by the rings l and l_1 made of insulating material. The outer plate cylinder k is provided with grooves, at the three parts of the periphery which lie symmetrical, where the friction rollers and driving wheels must be in contact with the iron cylinder. It is further fixed to the brass plates m, m, m, which at their ends are connected with the frame $n\,n$, so that the iron ring can freely rotate in the closed ring-shaped space, which is formed by the brass plate cylinders k and k_1, and the insulating end rings l and l_1. The free remaining portion of the cylindrical shaped hollow space between the three brass plates m, m, m, which surrounds the iron cylinder, is wound with insulated wire in the usual way. The wire is divided into 18 (as shewn) or more or fewer divisions, the ends of which have the 36 springs $o\,o$, which are so fixed to the ring p which is formed of insulating material, that two opposite springs are always in contact at their ends. The commencement of each wire division is always connected with one spring of one side of the ring, the corresponding wire end with the spring on the other side of the insulating ring so that the whole winding wire is closed through the touching contacts of the 18 pairs of springs. The springs are arranged so that the whole of their contact places lie in a plane standing at right angles to the main axle of the apparatus. On this axle itself rest two thin projections r and r_1 of brass with the corresponding friction rings s and s_1. These separating knives are covered on the one surface with insulating material (ivory, stone, etc.) or may consist of two metal plates insulated from one another. They are so arranged with their sliding rings on the axle that they stand in the plane of the spring contacts, and by the rotation of the axle pass through between the springs, and two pairs of springs at least are always separated from one another. As the insulated side pieces of both knives lie on different sides, the consequence is, that the circuit is broken through them, at two parts lying opposite to one another. The current is for one half of the wire spirals simultaneously directed through the conducting side of the knife, the sliding ring belonging to it and the contact springs t and t_1 sliding on them, whilst the other half remains continuously

interrupted. The knives are so arranged around the axle that one interrupts the winding wire of that division of the wire, and connects it with its sliding spring, which stands exactly over the brass segment of the rotating cylinder, whilst the other is so arranged that the action of the machine is at its greatest. If the iron plate bent into an open ring retains a small quantity of magnetism and if the cylinder is turned in the right direction, there appears a current in the coils of the closed side, which acting increasingly on the magnetism of the iron core brings about the dynamo-electric strengthening of the magnetism and with it of the current traversing the windings. If the spring ring is on the contrary so arranged, that the springs can be turned in the opposite direction, the machine is set in rotation by a current traversing it, it therefore serves as an electro-dynamic motor. To strengthen the magnetic field of the electro-magnets bent into the form of the cylinder, a length of iron wire is wound over the wire spirals. By placing an iron tube in the space within the windings, this strengthening action may be still further increased. If the machine is so arranged, to serve as an electro-dynamic machine (or electric motor) and if the direction of turning can be altered at will, the springs must be so fixed, as to allow of rotation in both directions, and each of the two surfaces of the knife insulated from one another must be provided with a slide ring. Reversing the direction of rotation is then effected through the change of the pair of slide rings employed.

As with this machine, the same wire which effects the magnetization of the iron produces also either current or force, less energy is lost with it by heating, non-current, or force producing wires than with previous dynamo-electric and electro-dynamic machines. In the same way the advantage is also secured, that the inner portion of the winding wire exerts the full magnetizing action on the iron of the whole magnet. This is also the case if the rotating cylinder is formed of two or more iron plates separated by non-magnetic material instead of a piece of iron bent into a circle, as the direction of magnetization remains the same with all the magnets, consequently the inner wires act magnetizingly also on all in the right direction. In this case the working coils of the several magnets must either be placed in parallel or if they must be traversed in series by

the current, a pair of knives with slide rings must be applied for each of the rotating magnets. Instead of using knives as described of which one side is insulated, they can be made altogether of metal in order to let a knife made out of insulating material follow the latter in the direction of rotation, which interrupts continuously that division of the winding wire which is not to be traversed by a current.

Claims.

1. The use of one or more circularly bent ring pieces of iron, which rotate between friction rollers within fixed windings.

2. The transference of the rotation of the inner cylinder consisting partly of iron to the axle of the apparatus through one or more toothed wheels fixed to the same, in which drivers gear.

3. The connection of the wire ends of the divisions of the winding wire into a closed wire coil through insulated fixed pairs of springs, which through their spring force are held in contact with another.

4. The continued conductive connection of the closed wire coils at two or more places with proper slide rings and the simultaneous breaking of it at other proper places through knife-like projections situated on the axle, which pass through the contact springs.

ELECTRIC ENERGY METER.*

The electric energy in a portion of a circuit, which is traversed by an electric current, employed for any purposes whatever is measured according to known principles by the product E J, that is, the strength of current multiplied into the difference of potential at the ends of the respective portion of the circuit.

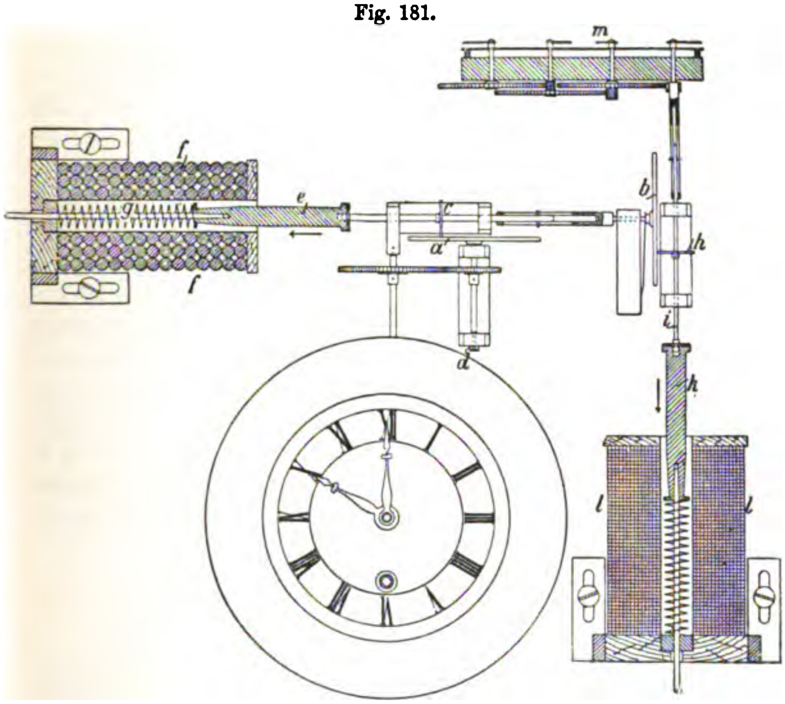
The apparatus shown in plan in the accompanying drawing

* (German Patent, No. 23349, of 17th September, 1882.)

(Fig. 181) has for its purpose, to register the sum of these products in terms of a unit of work to be chosen at pleasure.

The apparatus consists essentially of the two circular discs *a* and *b*. One of these discs *a* is turned uniformly by means of clockwork. On it rolls the little wheel *c*, against which the disc *a* is continually pressed by the spring *d* pressing against the end of

Fig. 181.



its axis of rotation. The little wheel *c* can be displaced from the centre of the disc up to its periphery by the iron or magnet bar *e* by means of the magnetic action of the solenoid *f*, when it is traversed by an electric current. The shifting is resisted by the spiral spring *g*. By a proper form and position of the iron core and of the spring *g*, the amount of the motion may become a measure of the strength of current in the solenoid. The velocity of rotation of the little wheel *c* is then also a measure of the strength

of current at that time. The axle of the little wheel *c* is so coupled at its other end with the axle of the disc *b*, that the displacement of the little wheel *c* is not prevented thereby. The velocity of rotation of the disc *b* is consequently also proportional to the strength of current in the solenoid *f*. On this disc *b* there rolls a second little wheel *h* with the movable axle *i*, the shifting of which is effected in the same way as that of the little wheel *c* through the iron or magnet bar *k* and the corresponding solenoid *l*. The velocity of rotation of the little wheel *h* is then again a measure of the strength of current in the solenoid *l*, when the disc *d* is uniformly turned by the little wheel *c*. Otherwise the velocity of rotation of the little wheel *h* is dependent on the amount of the shifting of both little wheels; it is therefore a measure of the product of the strength of current in both solenoids. If therefore one of the two solenoids forms a portion of the main circuit, so that the whole current J or a proportionate shunt from the same traverses it, and if the other solenoid is formed of fine wire of proportionately great resistance, which constitutes a shunt to the length of conductor the energy in which is to be measured, the attracting force of this solenoid, and consequently the amount of shifting of the corresponding little wheel from the centre of the disc to its periphery, is a measure of the difference of potential E at the ends of the length of conductor. The velocity of rotation of the little wheel *h* is consequently the desired measure of the electric work E J consumed in the length of conductor. By means of the counter *m* connected with the little wheel *h* the number of its revolutions is summed up so that the difference of two readings of the counter at all times gives the measure of the electric work consumed in the length of conductor during the time elapsed between them. The way in which the electricity is used in the conductor is therefore altogether without influence on the reading of the apparatus.

Instead of flat discs, which are always pressed by springs or weights against the little wheels, cones can also be used, along the sides of which the little wheels are displaced.

Instead of the iron or magnet bars, solenoids can be used to make the instrument available also for alternating currents.

Patent Claims.

In an electric energy meter with two registering wheels which roll on discs, of which one is uniformly turned by means of clockwork, whilst the other is set in rotation by the registering wheel of the first disc, the shifting of one little wheel by the main current and of the other by the current of a shunt of relatively great resistance in such a way that the distance of the little wheels from the centres of the discs is directly proportional to the strength of the currents.

IMPROVEMENT IN REGULATING ARRANGEMENTS.*

If a cylinder is movable in the direction of its axis of rotation, a roller which rolls on its surface under strong pressure, exerts no pushing influence on the rotating cylinder, when the axis of the roller is parallel to the axis of the cylinder. But if the roller is turned round somewhat, so that the plane of rotation of the roller is no longer perpendicular to the axis of the rotating cylinder, the touching point between the roller and the surface of the cylinder describes a spiral on the latter (Fig. 182).

This spiral is right or left handed according as the roller is turned to the right or left.

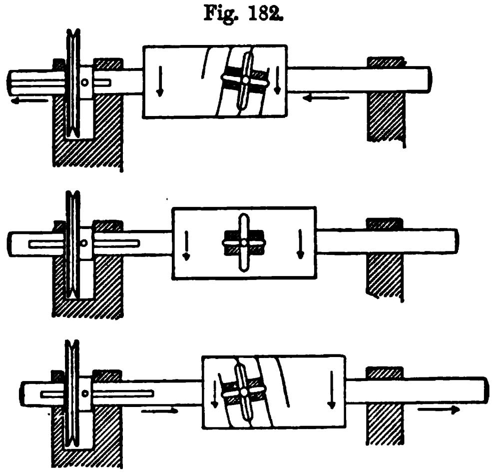
As the roller revolving in its bearings cannot change its position, the cylinder must move to the right or left in the direction of its axis, according to the twist of the spiral. This motion lasts as long as the oblique position of the roller, and changes its direction, if the roller is turned in the opposite direction out of its position vertical to the axis of the cylinder. The force with which the displacement of the cylinder takes place, is equal to the amount of friction between the roller and cylinder ; it is therefore very considerable, if the pressure between the roller and cylinder is great and the surfaces are not greased.

* (German Patent, No. 22613, of 30th September, 1882.)

But even in the last case the shifting force is considerable because the pressure is concentrated on one point, or at least on a very small surface.

This moving mechanism is specially suitable for the construction of governors for steam engines or other motors. If the axle of the shifting cylinder is connected with the throttle valve or the expansion gear of a steam engine, with the gas supply regulator of a gas engine, &c. and if the position of the roller is made dependent on the speed of rotation of the machine to be kept constant or its driving force, in such way that the roller is

Fig. 182.



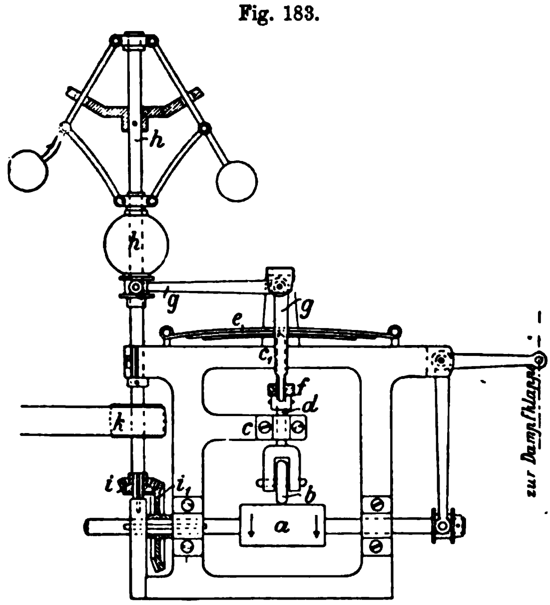
perpendicular to the axis of the cylinder with a normal rate or normal load of the engine, then the engine must after short variations of regulation return at once absolutely to its normal rate. As moreover for turning the roller even with very strong pressure against the wall of the cylinder only a very slight force is necessary quite independent of the resistance, which opposes the motion of the cylinder, a very slight regulating force is therefore sufficient, if the driving force of the regulating arrangement is a considerable one.

In the Figures 183–185 some arrangements of this regulating mechanism are shown.

Fig. 183 represents a steam engine governor in side view; *a* is

the movable cylinder on which the roller, *b*, turns, which can rotate in the bearings, *c* and c_1. The pressure of the roller against the wall of the cylinder is effected by the spring, *e*, which presses against the head of the pin, *d*, of the roller. The roller is turned by the arm, *f*, fixed to the pin, *d*, by means of the bent lever, *g*, the other arm of which gears in the sliding collar of a small Watt governor. By means of the mitre wheels, *i* and i_1, and the

Fig. 183.



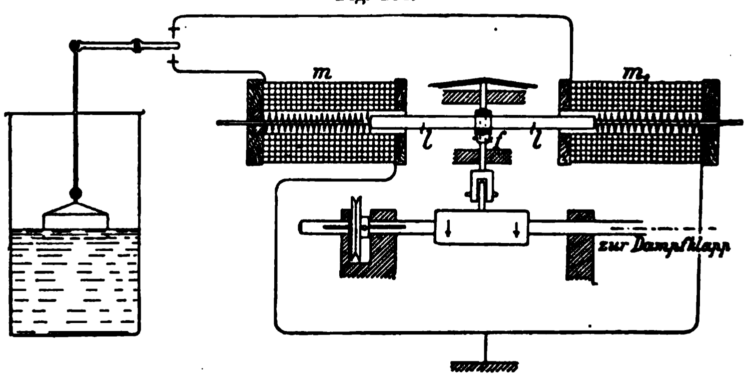
leather belt, *k*, both the movable cylinder and the governor spindle are set in motion. The rotation of the throttle valve or the setting of the variable expansion, takes place in any known way through the shifting of the axle of the cylinder. Only a very slight regulating motion is given to the regulator balls, as the roller, *b*, needs be turned only to a slight degree in one direction or the other, in order in a short time to give the necessary effective regulating motion to the cylinder, *a*, which brings back the rate of the engine absolutely to the normal velocity.

Fig. 184 shows the application of the described mechanism

to the regulation of the action of a pumping engine, which is to fill a distant reservoir up to a certain height. The arm, *f*, fixed on the pivot of the roller, carries in this case at its end a small iron cylinder, *l*, which is opposite to two solenoids, *m* and m_1. By means of a float in the reservoir an electric current is sent through the solenoid, effecting the closing of the steam valve, etc., when the float rises above the normal position, whilst a current traverses the solenoid, effecting the opening, when the float sinks below the normal position.

In Fig. 185 an arrangement is shown by means of which

Fig. 184.



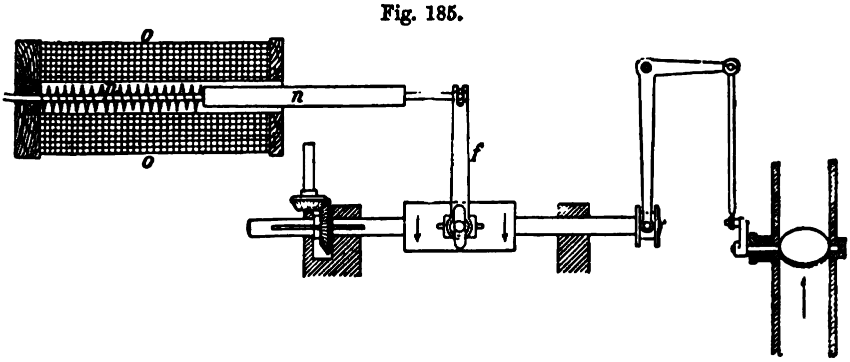
the velocity of rotation of the motor is to be regulated so that a solenoid is always traversed by a current of determined strength. Here the arm, *f*, is connected with an iron cylinder, *n*, which is attracted by the solenoid, *o*, when it is traversed by a current. By this means the spring, *p*, is pressed together to a degree corresponding to the strength of the current. If the arm is so arranged, that with the desired strength of current the roller stands at right angles to the axis of the cylinder, this strength of current must always be maintained.

If in an electric circuit, in which circulates a current generated by a dynamo machine, the strengths of current are to remain constant, this current, or a shunt from it, is allowed to circulate through the solenoid, *o*, wound with suitably chosen wire. If, on the other hand, the potential difference is to remain constant, the solenoid, *o*, is wound with fine insulated wire of great resistance,

and the latter is placed in a shunt to that circuit, in which the difference of potential is to be kept constant. If, finally, the electric output of the dynamo machine is to be kept constant, the iron cylinder, *n*, is replaced by a solenoid, and the main current is allowed to pass through one of the two solenoids, and that of the shunt through the other. The rate of the motor is then so regulated that the product of the strength of current and potential difference (therefore the electric work of the dynamo machine) is maintained constant.

Instead of one revolving roller two or more can be used,

Fig. 185.



which are so connected that they always remain parallel to one another. Further, for the reduction of the friction resistance of the axle of the cylinder, rollers can be arranged in their bearings on two sides of the rotating cylinder opposite to each other, which must then be turned in common in the sense of the screw line to be wound on the cylinder.

PATENT CLAIM.

The regulation of steam, gas, and other motors in such wise, that the work required to effect the regulation is directly supplied by the machine by means of the rotation of a cylinder movable in its bearings, whilst the slight regulating force shifting this in one direction or the other by the rotation of one or more loaded rollers, which roll on the surface of the cylinder.

ON THE HISTORY OF THE DYNAMO-ELECTRIC MACHINE.*

On the 17th January, 1867, I fully brought before the Berlin Academy of Sciences the theory of the dynamo-electric machine, after I had already in the beginning of December, 1866, shown such a machine in action in the factory to many members of the Academy. As I was not at that time a member of the Academy, Professor Magnus undertook to lay the matter before the Academy at its first meeting after the vacation (on the 17th January). This was the first publication of the principle, and in it the new name, "Dynamo-electric" machine, was first proposed by me. At my recommendation, and on the basis of my communication, my brother, Dr. C. William Siemens, sent at the end of January a communication on the subject to the Royal Society in London. About fourteen days later, Professor Wheatstone sent a paper on the same combination to the same Society. Both William Siemens and Wheatstone read their communications on the same day, William Siemens having given the prior notice. From this double communication it was held in England that Wheatstone and I had made and published the discovery simultaneously. This was entirely false, as my first publication through the Berlin Academy was quite a month earlier.

About a year later a provisional specification of the brothers Varley of the 24th December, 1866, became known, which had previously been kept secret. In this the dynamo-electric principle was in fact included. It was not discussed theoretically at all, and the one essential principle—the strengthening of the current by reversing the motion of the machine—was not once mentioned. According to English patent law, this provisional specification gave the brothers Varley commercial rights. In science, however, the principle introduced by Arago, and adopted by the French Academy, which is generally accepted, holds good, viz. that a right of priority belongs to him who has first communicated a new idea in a clearly comprehensible manner through

* (Journal of the Verein deutsches Ingenieure, Vol. 26, p. 671. 1882.)

printing or communication to an Academy or Society which publishes its proceedings. Even if it is assumed that Varley and Wheatstone discovered the dynamo-electric principle contemporaneously with me, or even earlier than I did, or had practically used it, still the priority belongs to me alone, for I first made the publication for the public benefit. If, moreover, Wheatstone's son-in-law, Mr. Sabine, asserts that he had already discovered the principle early in the year 1866 he has not produced any proof of it. If the apparatus brought before the Royal Society in February, 1867, was already made in the previous summer by Mr. A. Stroh, this indeed proves nothing. That which the mechanic made, was a magneto-electric exploder with Siemens' armature, such as had been made for years. It only became a dynamo-electric machine by the connections. Such data cannot prove claims of priority. Still less tenable are the data contained in the French journals, according to which Hjorth, Pacinotti, and others had already used the dynamo-electric principle earlier. Both have only described magneto-electric machines, in which steel magnets produced the original current, which the first, and later also Wilde, then strengthened by means of electro-magnetism.

These are the actual data on which my claim of priority rests. If no opposite certified facts are brought against it, I maintain it and will support it against any one. Besides, any one who has read my publication of the 17th January, 1867, will allow that it contains a perfect theory of the thing, that it gave results practically carried out, and already referred to its great importance. That a certain design is not wanting in obscuring my claim to priority follows from the exhibition reports, which were communicated to the Society of Telegraph Engineers. Mr. Sabine himself, under the title "Original Dynamo-electric Machine," after he had stated Wheatstone to be the inventor and first maker of this machine, does not say a word of the paper of my brother, Dr. C. William Siemens, which was sent in and read before that of Wheatstone, and only refers to mine at the end in a short remark: "Dr. Siemens read a paper before the Berlin Academy of Sciences on the same subject."

As Mr. Sabine, who was my pupil and for many years in my employ, knew exactly the facts of the case, I have certainly a right to complain of a certain national prepossession in this case.

ENERGY METER.*

If an iron ring at any part of its circumference is brought into direct connection with one pole of an electro-magnet, the whole ring uniformly assumes the magnetism of the magnet pole. The action of the ring magnetism on an electric current surrounding the ring is therefore the same at every part of the ring. A coil of wire sliding on the ring which is traversed by a current therefore acts with uniform force over the whole ring, up to the point of junction of the ring with the magnet pole. If the magnetism of the magnet and of the ring still falls considerably short of the maximum magnetism of the iron, it is proportional to the strength of the current in the windings of the electro-magnet; the force which acts to shift the coil of wire sliding on the ring is therefore, for each position of it on the ring, proportional to the product of the strength of current in the windings of the magnet, and in those of the moving coil. This combination can therefore be made use of in all electrical energy meters, by which the product, E J, is to be measured or continuously registered. In the energy meter represented in the drawings (Figs. 186 and 187) this takes place in the following manner:

The iron ring, A, is fixed to the free pole of the electro-magnet bar, B. Through the middle of the iron ring passes the iron axle, C, which is centrally suspended from two spiral springs, D and E, which are insulated from one another. To reduce oscillations and for proper suspension the axle is hung also from a thread, F, with a tension arrangement. The two wire coils, G and H, are so fixed to the iron axis, that they can turn around the ring without friction. The electric current is conducted through the spiral springs, D and E, to the coils provided with fine wire windings. There is a small iron shoe on the under side of the vertical hanging iron axle, C. This attracts the small movable armature, I, connected with the axle, C, by means of a brass stirrup, when the suspended axle is magnetized by the magnetism of the iron ring. If the magnetism of the ring

* (German Patent, No. 25919, of 12th July, 1883.)

and electro-magnet ceases, through the interruption of the current circulating in their windings, the little armature falls again. In this way a small knife fixed to the armature gears in the fine teeth of a crown wheel suspended just under the armature, and centrally as regards the suspended iron axle.

Fig. 186.

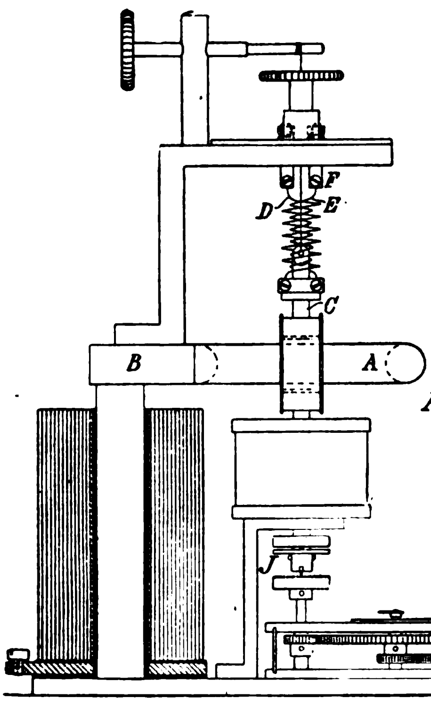
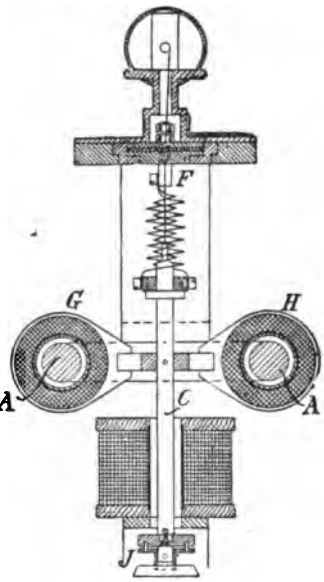


Fig. 187.



This little wheel is consequently connected with the axle, and takes part in its rotation so long as the electro-magnet is non-magnetic, and is separated from it so long as a current traverses its windings. By means of wheel work the revolutions of the little wheel are transferred to a counter. If, consequently, a shunt from the main current passes through the spiral springs and the suspended coils, and a shunt current from the whole length of conductor, in which the consumption of energy is to

be measured through the windings of the electro-magnet, the counter registers the sum of all the revolutions of the axle with the coils if the shunt of the main current is closed and opened at regular intervals. As the force, with which the spiral springs, D and E, oppose the motion of the coils, increases proportionately with the angle of rotation, the amount of rotation of the axle is also proportional to the product, E J, the counter gives therefore the desired sum of the energy expended, when the constant of the apparatus is once determined. If it is wished to interrupt, not the current of the electro-magnet, but that of the coils, which with the great variations in the strength of the current on account of the magnetism remaining in the iron ring is more judicious, there must be set over the suspended iron axle a fixed coil wound with two wires of which one wire is traversed by the current of the magnet coil, the other by the current of the swinging coil. The first wire is then so adjusted that the magnetic influence of the electro-magnet on the iron axis is exactly balanced, by the windings of the corresponding wire coil. The small armature carrying the knife is then attracted and allowed to fall, whenever the current passing through the coils is closed or broken.

This closing and opening of the current in regular alternation, can take place by any clockwork, which can itself be set in motion by the current. It is preferable however for this purpose to employ a sort of mercury electric clock. This consists of a glass tube, which is drawn out in the centre to a capillary tube. If the tube is half filled with mercury and then exhausted and sealed, the mercury as in a water balance, will flow into one or other side of the tube according as it is inclined to one side or the other. This variable inclination is effected by an electro-magnet, which inclines the tube fixed so as to rotate about an axle to one side, when a current passes through the windings of the electro-magnet or with the help of a spring is carried back to the other side when the current is broken. The mercury effects this opening or closing in a tube leg by means of platinum wires fused into it.

Instead of using a drawing back spring, two small electro-magnets can also be used, and for their magnetization contact wires can be melted into each half of the tube.

PATENT CLAIMS.

1. The use for electric energy meters of ring-shaped magnet poles in combination with coils rotating round them.

2. The suspension of the current measuring coils by two metallic spiral springs, which simultaneously serve as torsion springs and conductors.

3. The use of a small magnet armature in combination with the current measuring coils in such a way, that during the turning of the coils in one direction, their connection with a counter is made, and during motion in the opposite direction it is broken.

4. The production of currents at regular intervals of time, by automatic tipping of a glass tube partly filled with mercury and exhausted, which is supplied with contact arrangements for regulating the activity of an electro-magnet.

ON A NEW METHOD OF RAISING WATER.*

GENTLEMEN,—I beg you to give me a few minutes hearing to make a short communication on a new method of raising water which I have applied with satisfactory results. It was a question of draining a seam of brown coal in the neighbourhood of Berlin, which is covered with a stratum of fine running sand more than 30 metres deep. Mr. Potsch's method for sinking a shaft, which consists in freezing the wet sand by tubes sunk in it, in which a strongly cooled liquid is continually allowed to circulate, and then in sinking the shaft in the hard-formed mass in the mining method was so far successful, that the shaft could be carried without break to the coal bed lying some 30 metres deep; yet when the protection of the frozen covering ceased, the penetrating water could no longer be kept back, and the shaft filled with water mixed up with sand. To complete the work and to make a safe working of the coal bed possible, the most suitable method

* (Communication to the Society for the Advancement of Industry, on the 2nd March, 1885.)

seemed to be to withdraw continually from the ground, the water pressing up from all sides in the sea of sand open on all sides by a system of Artesian wells, and in this way to remove the pressure of water at the rupture. Force pumps of great efficiency cannot be well applied in the narrow conduit pipes. A valve pump system driven by compressed air promised much better results, but the efficiency of the single wells always appeared too small in comparison with the amount of water to be overcome.

These necessities led me to think of imitating the method so frequently used by nature itself in geysers, fountain sources, petroleum springs, of raising the liquid by the production of gas below, and by supplying compressed air in the sucker of an Abyssinian tube to produce an artificial geyser spring. This plan found sympathy neither with theorists nor practical men to whom I communicated it, and a certain force of conviction was necessary to carry it out.

The result however has completely satisfied my anticipation, as you will see if you will inspect an Abyssinian well provided with air expulsion at the factory of Siemens & Halske, to which I hereby invite the gentlemen interested in the subject. The Abyssinian well already long existing has a tube bore of 80 mm., is sunk about 30 metres deep, and is provided with a sucker about 3 metres long. For these experiments the tube is supplied with an extension about 9 metres above the ground; the air compressed by a locomotive driven in the opposite direction, is led below the tube to a sucker, by means of a lead tube of 2cm. interior diameter, the lower end of which is provided with a copper tube closed below, having many fine holes for the exit of air.

As soon as the air is compressed to 3 atmospheres pressure in the boiler of the locomotive, it enters the tube filled with water up to the ground water level, and rises slowly up in it, in many fine bubbles. As each bubble exerts a pressure on the water above it equal to the weight of the water removed by it, the balance in the communicating tube system formed between the tube and the ground water by the driving up effected by the collective bubbles is disturbed, the water must rise up in the tube, until equilibrium is again brought about with the pressure of the ground water, or if the tube is not so high it must pour out

above and enter through the sucker with a velocity corresponding to the remaining balance of pressure.

This velocity is constant if the influx of air is constant and is dependent on the quantity of air passed through in the unit of time, and the friction resistances in the tube and the sucker. It must be remarked, that the air bubbles, whilst they rise quickly up with the current of water, gradually expand again to atmospheric pressure, and therefore remove a considerably larger quantity of water. For the driving up effected by the pumped in air, therefore, the mean density of the air in the tube is to be calculated. If the water consequently is to be raised by half the height of the ground water measured from the sucker, then in order to obtain hydrostatic equilibrium, the specific gravity of the mixture of water and air in the pipe must be $\frac{2}{3}$ on the average, therefore to effect this, air of the density of half the height of the ground water must be passed through equal to $\frac{1}{3}$ of the volume of water entering by the sucker or equal to $\frac{1}{6}$ of the volume of water in the case of air compressed to the full height and coming in below. For the acceleration of the water up to the exit velocity, and for overcoming frictional resistance in the pipe and sucker, this volume of air must be correspondingly increased.

This increase of the necessary quantity of air for the production of the motion of the water forms indeed the loss of work to which is to be added the loss of work through heating of air on its compression, and a further loss which depends on the relation of the velocity with which the air bubbles stream out in still water to the velocity with which they rise in the flowing water. If the air enters the water through many fine openings, so that the bubbles are small, therefore rise slowly in still water, and if the velocity of the water is considerable the last-named loss of work is only unimportant. In the experiments carried out, a quantity of water of 600 to 700 litres was raised through the tube 80mm. wide, and a velocity of water was attained of 2·5 metres per second. In reality the velocity is still greater, for the water, specially in the upper part of the pipe, is mixed with a large quantity of air, and is thrown out as a heavy homogeneous froth from the mouth of the tube. It has not been possible to make a calculation of the economy of this method of raising water, and it will still require many experiments in order to arrive at the best proportions of

the dimensions of the tube and sucker, of the length of tube to the height of lift of the water, and the quantity of air to be driven in. One can however already assert positively that this new method of raising water in many cases, and especially in mining, for the irrigation of land, etc. will find advantageous application. It is also not limited to use with Abyssinian wells, but everywhere applicable, where by digging deep wells or immersing deep tubes from the bottom of which the pumping tube rises a communicating tube can be set up below the level of the water to be raised, of at least half the height of the pumping tube.

IMPROVEMENTS IN THE ELECTROLYTIC EXTRACTION OF COPPER AND ZINC.*

COPPER has hitherto been obtained by electrolytic means in such a way, that either plates of impure copper or of copper matte, have been used as anodes. Then copper or iron and copper was dissolved at the anode by the electric current, and at the cathode copper was electrolytically deposited. In the latter case however the solution soon becomes very poor in copper and must be replaced by a new solution, the production of which from the ore is attended with expense and difficulties of many kinds. Besides making the anodes of fused copper matte necessitates a previous smelting process of the roasted sulphuretted copper ore; the casting of the anode plates is difficult and uncertain, and the electrolytic process is much interfered with by the crumbling of the anodes before their complete solution.

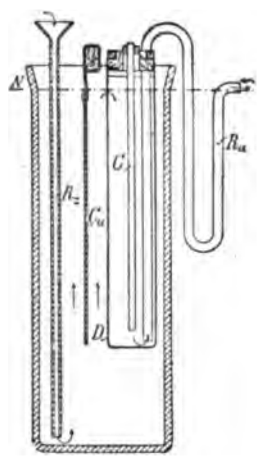
In contrast to former processes in which soluble anodes served for the purpose of depolarization, our process consists in the use as a depolarizing medium of a liquid in combination with insoluble anodes, and in separating the copper salt to be decomposed at the cathode, from the liquid to be oxidized at the anode, by means of a non-metallic diaphragm. The liquid to be subjected to electro-

* (German Patent, No. 42243, of 14th Sept. 1886.)

lysis consists of a solution of sulphate of iron and sulphate of copper, with the addition of some free sulphuric acid to improve its conductivity.

This liquid is best introduced continuously near the bottom of the liquid surrounding the cathode plates, when separate decomposition cells are used, it rises up from here whereby a portion of the copper is deposited metallically on the cathodes by the electric current, and it then flows over the upper edge of the diaphragm

Fig. 188.



into the anode space, through which it flows down to be again drawn off at the bottom of the latter.

During this descent the ferrous sulphate is first converted into basic ferric sulphate, and then by taking up sulphuric acid set free by the decomposition of the sulphate of copper is changed into neutral ferric sulphate when the latter owing to its greater specific gravity sinks to the bottom along the carbon rods or plates. The outflowing liquid has therefore become poorer in copper, and consists partly of a solution of neutral ferric sulphate. This solution has now the property of converting cuprous sulphide, cupric sulphide as well as cupric oxide into copper sulphate. Thus with the first of the solutions of the two copper compounds, the ferric sulphate is changed back into ferrous sulphate, whilst the free

oxygen oxidizes the cupric sulphide. By the previous roasting of copper pyrites at a low temperature a product has been obtained in which the copper is mostly contained as cuprous sulphide, but the iron as oxide, therefore the latter in a form which is not acted on at all by ferric sulphate, and only slightly by sulphuric acid, whilst the cuprous sulphide is energetically dissolved by ferric oxide solution.

Our process of obtaining copper consists consequently in roasting the copper pyrites in the form of powder at a low temperature, preferably in a Gerstenhœfer's furnace, until the iron is almost entirely oxidized, whilst the copper exists partly as copper sulphate, partly as cupric oxide, but for the greatest part as cuprous sulphide in the roasted ore. The powdered roasted ore is now lixiviated with the liquid flowing out from the galvanic decomposition cells. This lixiviation is carried out best in a series of lixiviating vats, which are flowed through one after another so that the lye flows last through the vat last charged with roasted ore. The solution thus freshly enriched with sulphate of copper, in which there is no more iron oxide salt, is now again brought back to the galvanic decomposition cells, is therefore again deprived of its copper, then oxidized, then led anew through the roasted ore to take up fresh copper. It is therefore a continuous process in which the same liquid can serve until by the taking up of foreign metals existing in the ore it has become too impure for the galvanic depositing process.

The following equations make clear the chemical reactions occurring in the electrolytic and lixiviating processes :—

1. Reactions during electrolysis :

$$x\,H_2\,SO_4 + 2\,Cu\,SO_4 + 4\,Fe\,SO_4 =$$
$$2\,Cu + 2\,Fe_2\,(SO_4)_3 + x\,H_2\,SO_4.$$

2. Reactions during lixiviation :

$$x\,H_2\,SO_4 + Cu\,S_2 + 2\,Fe_2\,(SO_4)_3 =$$
$$2\,Cu\,SO_4 + 4\,Fe\,SO_4 + S + x\,H_2\,SO_4. \qquad (\alpha)$$
$$Cu\,O + H_2\,SO_4 = Cu\,SO_4 + H_2\,O. \qquad (\beta)$$
$$3\,Cu\,O + Fe_2\,(SO_4)_3 = 3\,Cu\,SO_4 + Fe_2\,O_3. \qquad (\gamma)$$
$$Cu\,O + 2\,Fe\,SO_4 + H_2\,O =$$
$$Cu\,SO_4 + (Fe_2\,O_3 + SO_3) + H_2 \qquad (\delta)$$

If the equations 1 and 2 α are compared, it is seen that if the

ore contains the whole of the copper in the form of cuprous sulphide, the electrolytic liquid, after passing the lixiviating vats, contains exactly the same quantity of sulphate of copper, sulphate of iron, and free sulphuric acid as before the electrolysis, that it is therefore entirely regenerated, and can be used anew for electrolysis. If, on the other hand, the copper partly exists as copper oxide in the ore, it is seen from the equations 2 $\beta\ \gamma\ \delta$ that in this case after the lixiviation the electrolytic liquid has become richer in copper, but poorer in iron and free sulphuric acid than before the electrolysis.

It needs hardly to be mentioned, that in place of the roasted copper ore unroasted ore can be used for the lixiviation, in which the copper exists almost exclusively as cuprous sulphide. In this case, however, not only is copper dissolved, but iron also, so that a complete constancy of the solution in copper and iron is not obtained.

It is to be remarked here that no polarization takes place in the galvanic process described, and also that the different positions of the anode and cathode in the tension series does not cause an electrolytic counterforce.

Whilst, with the use of copper ore anodes, a potential difference of about 1.5 volt is necessary; in the processes described only a potential of about 0.7 volt is necessary with the same current density. Whilst, further, by the use of copper ore anodes, about one-third of the current is expended for effecting other reduction processes and so becomes lost, in the process described there is no loss of current.

The same process can further be used for obtaining zinc electrolytically from zinc sulphide ores with the help of a solution of sulphate of zinc and sulphate of iron. There is formed in the electrolytic decomposition cells zinc and ferric sulphate according to the equation

$$Zn\,SO_4 + 2\,Fe\,SO_4 = Zn + Fe_2\,(SO_4)_3.$$

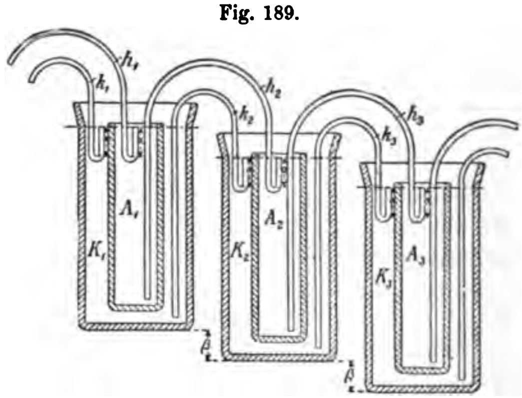
The ferric sulphate thus formed now possesses the property of dissolving zinc from slightly roasted zinc sulphide, whilst sulphate of zinc and ferrous sulphate are formed according to the equation

$$Zn\,S + Fe_2\,(SO_4)_3 = Zn\,SO_4 + 2\,Fe\,SO_4 + S.$$

A comparison of this with the previous equation shows that after the lixiviation of slightly roasted zinc sulphide ore by the electrolytically oxidized liquid, the percentage of zinc and iron becomes again as great as before the electrolysis. Anyhow, in this zinc process the necessary potential difference between anode and cathode of the electrolytic bath is about double as great as in the previously described copper processes because of the electric difference of potential between zinc and carbon.

The new facts lying at the basis of the described processes, viz., that oxidizable solutions conducting electricity become oxidized

Fig. 189.



to a higher degree under certain circumstances on an anode consisting of carbon (or also platinum, gold, &c.), by the galvanic current without the appearance of polarization, may be used for other chemical operations if the decomposition apparatus is so arranged that the liquid to be oxidized circulates in the cells surrounding the anodes, while the liquid in those surrounding the cathodes has to be reduced. As it is more convenient in general to produce and employ electric currents of high tension, which necessitate the placing of a large number of decomposition cells in series, it is necessary to arrange a flow of liquid through the decomposing vats in such a way that in the first place the regenerated liquid flows through all the cathode cells in succession, that then the same liquid is led through all the anode cells, and finally through the regenerating tank filled with roasted ore. It hence

results that there is no iron oxide salt in the liquid filling the cathode cells which would be reduced by the current and would consequently interfere with the copper depositing, as well as with the enrichment with iron oxide salt in the final lixiviation.

In order to obtain a quick current of liquid through all the cells, which is necessary for good working, we arrange the rows of decomposition cells in the shape of a staircase (Fig. 189), and connect all the cathode divisions K_1 K_2 K_3 as well as all the anode divisions A_1 A_2 A_3 of the cells with one another by the syphons *h* and *k*. In order to maintain the level in all the vessels independently of the supply, the syphon limbs leading to the cells standing lower are bent upwards by a piece α, which is equal to the difference of height β between two consecutive cells.

PATENT-CLAIM.

In the electrolytic extraction of copper and zinc the lixiviation of the powdered roasted, or smelted sulphurous ore by means of ferric sulphate, which is itself produced in the baths, whilst the course of the electrolyte, consisting of copper or zinc sulphate and ferrous sulphate, is so arranged that in the first place the cathode cells are flowed through to deposit copper or zinc, then the anode spaces, provided with electrolytically insoluble anodes, for the purpose of converting the ferrous sulphate into ferric sulphate, and finally the corresponding ore, after which the regenerated liquid is again brought back to the cathode cells.

THE AGE OF NATURAL SCIENCE.*

GENTLEMEN,—The Society of Natural Philosophers and Physicians, so numerously and brilliantly represented here, raised the banner of free investigation for the first time in our Fatherland sixty years ago, and by its meetings in different parts it made the

* (Address at the 59th Meeting of German natural philosophers and physicians on the 18th of September, 1886.)

sciences—up to then only pursued in the limited circle of scientific specialists—accessible and therefore serviceable to public life. This was an important step in advance. With it began a new era for mankind, which we are right in calling the age of natural science.

It is true nature itself had bestowed on primitive man, corporeally but feebly equipped, power of mind and talent of observation as the most powerful of all weapons for his struggle for existence, had directed him already to the utilization of natural forces, and the increasing knowledge of their judicious employment had already in early ages pointed out to mankind the way to higher culture. The arts of earlier periods could even develope in many departments to a height which is wonderful even to-day; it could in particular produce the means for artistic performances of still unattained perfection; but this always took place by the arduous and in many ways misleading method of collecting purely empirical observations, and misunderstood and unconnected experiences, therefore by a way which could only slowly lead to the development of higher grades of culture.

These manifestations of culture were therefore mostly developed in limited areas, and they wanted permanence, since experience and skill are personal and die with the individual. Hence we see in the course of time many culture-epochs arise locally limited and vanishing in the storms of following ages almost without leaving a trace. And yet, later—after intellectual acquisitions had become through the arts of mechanical multiplication by writing and illustration a permanent general property of mankind, and after the bases of our present scientific knowledge were laid by great geniuses, and we had already become assured that invariable fixed laws lie at the basis of all natural phenomena, and that the only safe way to learn these laws consists in questioning nature itself by properly conducted experiments—even then scientific and technical advance was arduous, slow and uncertain. It needed the entry of science into public life: it was necessary that the purely empirical arts should be penetrated by the genius of modern science, to free them from the laws of custom and trade, and to raise them to the heights of natural science.

We older ones among you have had the good fortune to witness the stupendous progress in almost all departments of life under

the stimulating influence of the breath of natural science. But we have also seen how at the same time science again on its side was aided by technical advances, as engineering brought to it an abundance of new phenomena and problems, and with it the incitement to further investigations, and how with the extension of scientific knowledge a body of observers and workers arose, who perhaps do not stand on the summit of scientific knowledge, but in whom often the love of science knew how to overcome this want.

I will not undertake to bring before you here the history of the progress of science and of its application to the arts, nor to describe the powerful transforming influence, which science and the arts combined have exerted on the spiritual and material development of our time. This has already frequently been done in convincing language and in masterly form; bringing together all the phenomena appertaining to it, in a picture only in a slight degree exhaustive, could only be done by sketching the history of our culture, and would extend beyond the problem set me to-day, which consists in helping to dissipate the apprehensions which latterly have frequently been made public with respect to scientific technical progress.

For us elders it is only necessary to cast a short retrospect over our own youth in order to survey the great difference between then and now. We still remember the time when steamers and locomotives made their first slow journeys; we then heard with unbelieving astonishment the news that light itself was to paint the picture which it makes visible to our eyes; that the mysterious new force, electricity, forwarded news with lightning-like speed across whole continents and the oceans separating them; that the same force separated metals in the solid form from their solutions and was able to illuminate the night like day. Who wonders to-day about these things now matters of course, without which our youth can now hardly imagine a civilized life, at a time, when according to Reuleaux's calculation, several iron workers toil day and night for each civilized man, when moved by subjugated natural forces many million men daily meet one another, who were separated yesterday by a wide distance, and when immeasurable quantities of goods are carried by land and sea through mountainous districts and over their

summits and defiles at a rate previously hardly imaginable; when the world-connecting telegraph is no longer sufficient for our commercial requirements, and the carrying of living words by the telephone must spread over tracts in comparison with which the limits set by nature to the human voice fall back as quite insignificant, when the most recent fruit of the combination of science and the arts, electric engineering in its rapid development is ever opening up to mankind new provinces still quite unbounded in their limits for further enquiry and useful application of the forces of nature. For the natural philosopher, who is accustomed more than other classes of mankind to draw conclusions from the course of observed phenomena as to the law governing them, it is not the last development, but the causes and the law limiting the same which are of paramount importance.

This clearly discernible law is that of the uniform acceleration of our present development of culture. Periods of development, which in earlier times were only traversed in centuries, which even at the beginning of our century needed tens of years, are now completed in years and enter frequently into existence in full perfection. This is, on the one hand, the natural consequence of a phenomenon of our progress of culture itself, namely, of the present highly developed system of instruction especially in our Fatherland, by which the acquisitions of science, but especially scientific methods, are conveyed on the broad current of engineering to public life generally in all its forms of activity, on the other hand the effect of self-renovating scientific technical progress. And so we observe how to-day every new scientific thought, born of its mother in everlasting re-birth, hastens through the civilized world, how thousands seize it and seek to apply it to the most different departments of life. If sometimes they are only insignificant observations, sometimes only the vanquishing of quite small obstacles which have opposed the knowledge of the scientific connection of the phenomena, often they are starting points of a series of developments hardly to be foreseen and highly significant for the life of mankind. The acceleration of progressive development thus brought about, will, therefore, continue as long as natural science itself marches to higher degrees of knowledge unless man in his presumption himself disturbs it. The deeper insight we gain into the mysterious rule of natural

forces, the more convinced we are, that we are standing only at the porchway of science, that a quite immeasurable field of work lies before us, and that it appears at least very questionable whether mankind will ever arrive at a full knowledge of nature. No ground therefore exists for doubting the continuation of the accelerated flight of scientific and technical development if mankind does not cross it through deeds inimical to culture. Yet even such hostile encroachments can henceforth only cause temporary breaks in development, at the most only short locally limited retrogressions; for before that light of science, penetrating always deeper into all classes of the profession and of the people, not only the children of the old darkness, superstition, and prejudice, recede further and further back and lose gradually their own power to hinder and disturb the way of development, but thanks to printing and the present extensive spread of modern culture the scientific and technical acquisitions of mankind cannot again be lost. Those people who cherish and cultivate them also gain thereby so powerful an ascendancy, such a preponderating fulness of power, that their succumbing in the battle against uncivilized peoples, and the breaking in of a new barbaric period, appear to be quite excluded.

But, whilst we must regard the present extension of culture as continuous and indestructible, the final aim still certainly remains concealed for which this progress struggles: we can, however, recognize the road of progress itself, in what direction it must alter the former bases of domestic life. For this purpose, it is only necessary to follow out further the changes that have already taken place. We thus easily recognize that, in the period of the dominion of science, the heavy corporeal labour by which mankind was to so great an extent hampered in the battle for existence, and to a great extent still is, is more and more avoided by the increasing use of natural forces in the mechanical performance of work, that the labour falling to man is always a more intellectual one, as he has to direct the work of the iron toiler, but has not himself to perform heavy corporeal work. We see further, that in the scientific age, the necessaries of life and articles of enjoyment are produced with much less physical labour; that therefore also with less working time a greater share of these productions of labour falls to each individual. We find that the progress

of natural science acting on the arts and commercial life makes possible an always easier interchange of the products of different lands and climates, which makes the life of mankind take a more enjoyable form, and secures its existence against the consequences of local scarcity. We see that man is able to gain by scientific and technically properly directed culture of the soil a considerably greater quantity of the means of subsistence than formerly, so that the number of men assigned to it may be much greater; it appears, therefore, very probable that chemistry in combination with electric engineering will one day succeed in producing out of the inexhaustible supply of the elements of food stuffs existing everywhere these latter themselves, and so make the number of those to be nourished independent of the final power of endurance of the ground.

This progressively increasing ease of gaining the material means of existence on account of the shorter time of labour which he has to employ for that purpose, will afford to man the necessary surplus of time for his better intellectual improvement and intellectual enjoyments; the knowledge of the conditions for bodily well-being increasing with the knowledge of the working of the forces of nature, will lead to the more healthy development of the future of the human race in body and mind; the mechanical reproductions of artistic productions, which are always becoming more perfect and more easy, will facilitate their introduction into cottages, and the art which beautifies life and raises civilization will be available for the whole of mankind, instead of, as formerly, being only accessible to the upper classes. If we then hold fast to the conviction that the light of knowledge, always penetrating deeper into the whole society of mankind, subdues in the most effective way debasing superstition and destructive fanaticism, the greatest enemies of mankind, then we can labour further with proud joy at the building up of the age of natural science, in the certain assurance that it will supply to mankind moral and material conditions which are better than they ever were, and are even now.

The joy, however, is much spoilt for us in recent times by melancholy pessimistic views, which have been formed both in educated circles as well as among the masses, respecting the influence which the rapid development of science and engineering exerts

on the formation of the life of the people, and on the final aim of this advancement.

The questions are advanced and discussed, whether mankind is actually better and happier for all these acquisitions of science and the arts, whether these acquisitions do not rather lead to the destruction of all ideal good and to a coarse longing for enjoyment, whether the unequal division of goods and enjoyment of life would not be increased by it, whether by the advancement of mechanical industry, and the division of labour consequent on it, the opportunity of work for individuals was not diminished, and the workers themselves would not be brought into a more uncertain dependent position than formerly; whether, in a word, through it, in place of the dominion of birth and the sword, the still more depressing dominion of inherited or acquired possession is not set up?

It cannot be denied that at the present day these sad views must be admitted to have some measure of truth. The rapid and unceasing progress of scientific arts must act disturbingly by its development on many branches of industry. The improved methods of work often lead to goods being produced more quickly than they are consumed, and to the reduction of opportunities for work, whilst former hand-work, which for a similar production employed a much greater number of workers, comes into competition with the work of the specialized machine. Similar phenomena make their appearance in the production of food stuffs. The cheap means of communication bring to the old cultured lands in vast quantity the products of the soil of distant sparsely populated countries, the virgin soil of which does not require artificial fructification, in which, however, the want of a working population has matured the methods of mechanical treatment. In this way, however, prices are introduced, in the face of which our old methods of cultivating the soil by hand-labour cannot subsist. Certainly the scientific arts present the means of compensating these disadvantages by complete restitution to the ground of what is consumed, and by more rational methods of labour; but it is exceedingly difficult to replace by better ones relations and methods sanctioned by ancient custom although they have become untenable. We thus increase the complaints regarding the general lowering of prices and about the want of opportunities of work, and very doubtful theories are set up that,

by separating countries from each other, and by the forcible reduction of production the disadvantages experienced may be improved. The exponents of theories of that kind often even go so far as to deny the advantage to mankind of the scientific technical tendency of our time, and to dream of a return to the methods of work of earlier and presumably more fortunate times. They do not, however, consider in this respect that then also the number of men must be reduced to the former amount. The number of fortunate herdsmen and huntsmen which a land can nourish is, however, only small; and, in considering the greater or less prosperity of a period of time, this number must always appear as an essential factor. It is certainly a hard, but also, unfortunately, an immutable social law that all transitions to other, if even to better circumstances, are accompanied by suffering. It is, therefore, also certainly a humane beginning to alleviate these sorrows of the present generation by judicious management and partial restriction of the new irresistible breaking-up convulsions of the social bases of the life of the people; it would, however, be useless to attempt to interrupt the current of this advance, or to wish to turn back. It must necessarily follow its destined course, and those lands and peoples will be the least affected by its destroying action, and first participate in the benefits of the scientific age, which contribute mostly to its peaceful advancement. That this latter, however, really leads mankind to better conditions, that in its further progress it will again heal the wounds which it struck, is to be recognized already clearly in many phenomena, notwithstanding the unavoidable suffering during the transition to the new forms of life.

Is not the universally occurring phenomenon of the reduction in price of all the necessaries of life and products of labour, with their simultaneously greatly enhanced consumption, undeniable evidence that the manual labour necessary for their production is not only easier than formerly but has also become less? that therefore the direction of advance is such that mankind in future will have to work a yet shorter time in order to gain their means of subsistence. Does not the simultaneously occurring phenomenon that the price of labour does not sink equally with the price of goods prove an improvement in the lot of the worker with the advance of the scientific age? Cheaper production of the necessaries of

life is after all synonymous with the rise of wages. "Higher wages with shorter hours of labour," this ever louder ringing demand of the so-called working classes, follows as the natural consequence of the development. Then, setting aside crises and states of transition, no more necessaries are produced than are consumed, the average time of labour must therefore necessarily diminish with the increased rapidity and simplicity of its production.

Another phenomenon also universally occurring is the fall in the interest on capital. To survey the importance of this fact, one must keep in mind that capital (saved wages, as national economists properly regard it,) is the measure of all value of possession. Personal or borrowed capital enables mankind to make use of extra labour. If capital were actually abolished, as fanatical and mistaken men desire, mankind must return to the state of uncivilization, when each had to work with his own hands for the production of his requirements. However, the demand for capital cannot keep pace with the growth of the savings of labour, or capital, as the contrivances for obtaining the results of labour continue to grow more productive, simpler and cheaper. More capital, therefore, is always collected on the average—always excepting states of transition and violent disturbances of natural advancement—than can be usefully applied, or. in other words, an overproduction of capital takes place, which must find its expression in the steady sinking of the rate of interest, and, in fact, already finds it. Saved former work, capital will therefore sink continuously in value as regards work of the present, and must, therefore, destroy itself in the course of time.

For the further, and apparently most important, complaint of the opponents of our present social development, the assertion that through it the great majority of mankind was doomed to the performance of work in great factories, and that by the progressive division of labour there remains no space for free labour of the individual, also for this the natural progress of the development of the age of natural science has its own remedy. The necessity of large factories for the cheap production of articles of consumption is principally caused by the as yet small development of mechanical engineering. Hitherto large machines have supplied mechanical work much more cheaply than small, and the setting up of the latter in the dwellings of workmen is connected,

moreover, with great difficulties. Engineering will, however, infallibly succeed in overcoming this obstacle to the return to competitive hand labour, viz., by the introduction of cheap mechanical power, that basis of all industry, into small workshops and dwellings of artisans. A number of great factories in the hands of rich capitalists, in which "slaves of work" drag out their miserable existence, is not, therefore, the goal of the development of the age of natural science, but a return to individual labour, or where the nature of things demands it, the carrying on of common workshops by unions of workmen, who will receive a sound basis only through the general extension of knowledge and civilization, and through the possibility of obtaining cheaper capital.

Equally unfounded is the complaint that the study of science and the technical application of the forces of nature gives to mankind a thoroughly material direction, makes them proud of their knowledge and power, and alienates ideal endeavours.

The deeper we penetrate into the harmonious action of natural forces regulated by eternal unalterable laws, and yet so thickly veiled from our complete comprehension, the more we feel on the contrary moved to humble modesty, the smaller appears to us the extent of our knowledge, the more active is our endeavour to draw more from the inexhaustible fountain of knowledge, and understanding, and the higher rises our admiration of the endless wisdom which ordains and penetrates the whole creation. And the admiration of this endless wisdom calls forth again that endless desire for enquiry, that self-sacrificing pure love of knowledge, finding its last purpose in itself, which has always been the high ornament of the German student, and it is hoped will continue to be handed down to future generations.

And so, gentlemen, we will not allow ourselves to be shaken in our belief that our activity in investigation and discovery leads mankind to higher grades of culture, honours it and makes it more accessible to ideal efforts, that the incoming age of natural science will diminish its life troubles, its sickness, raise its life pleasures, will make it better, happier and more satisfied with its lot. Even when we cannot always clearly distinguish the way which leads to these better conditions, yet will we hold close to our conviction that the light of truth which we investigate does

not lead to error, that the access of power which it conveys to mankind cannot lower it, but must raise it to a higher grade of existence.

ON THE POSSIBILITY OF PRODUCING FOOD STUFFS BY MEANS OF ELECTRICITY.*

I HAVE, as is known to our older members, stated an opinion in a speech, which was intended for the Society of Natural Philosophers at Baden Baden, and which with the copy of my address forms part of the first part of our Journal for the year 1880, to the effect that in the future, in the times when coal, our principal fuel, comes to an end, it will become possible, by means of electricity, in combination with chemistry, to employ the elementary forces existing in nature for the production of transportable fuel, and thus to maintain the means of existence of mankind for a yet longer period. It might also be possible that in future means of existence could be produced from their elements existing everywhere. This opinion received little attention at that time, and has remained almost unnoticed. Recently, in an address to the Natural Science Assembly at this place, I have cursorily repeated the second portion of this opinion as applied to social conditions of life in later times. That has not pleased many of our national economist party. I have been violently attacked on this account, and people have considered this opinion as a pure picture of the imagination. I have not, however, been accustomed to give imaginary pictures without an actual serious background, and, therefore, consider it right to justify my opinion before you.

Science assumes at present that every body has required for its production a certain amount of work or energy. This energy has been created with matter itself with which it is combined, it is perpetual, and can as little as the latter be increased or diminished. When two or more bodies enter into chemical com-

* (Electrotechnische Zeitschrift, Vol. 7, p. 481.) 1886.

bination these require a greater or less amount of energy for their constitution than the bodies contained which are brought into combination. This surplus manifests itself as an alteration of the temperature of the newly-formed body. We can, therefore, produce sensible or free heat by bringing about chemical combinations, which require in their new constitution a smaller amount of energy than the bodies contained before their new chemical combinations. Such bodies, indeed, occur in nature as minerals, as, for instance, sulphur and combinations of sulphur with metals; they are, however, inconvenient for application as fuel and heating material. We are almost exclusively confined to plants and their residue, coal. The plants owe their growth to the energy conveyed to them by the light and heat rays of the sun. Stephenson could, therefore, answer quite properly, when asked what force made his locomotive go, "bottled sunlight." All the energy which we use on the earth, and by which we live, is energy borrowed from the sun, which we fortunately find collected in great masses in the great fields of coal and lignite. But even this store of useful energy will at last be expended, and there then arises the vital question for mankind whether the necessary fuel can be obtained by other means. By chemical means this is impossible, for by it energy can, indeed, be changed and extended, but not concentrated.

This, however, is altered by the application of electricity. If water is decomposed by the electric current of a dynamo machine, the current must supply the energy of combination which lies in the formation of water, so that the elements hydrogen and oxygen may be separated from one another, and can exist separately. This energy is imparted to the electric current by a steam engine, or some other form of motor, which drives the dynamo. Setting aside losses by friction, etc., the work provided by the motor must be as great as corresponds to the quantity of heat which can be produced by the combination of the oxygen and hydrogen. Therefore the same quantity of work is expended for the production of the electric current as can be brought back by the combustion of the products of decomposition. The same quantity of energy therefore remains in the world; only a transference of mechanical into chemical energy has taken place. The possibility, therefore, exists by the expenditure of mechanical force, with the

help of the electric current, to produce fuel. Hydrogen and oxygen—explosive gas—is an excellent fuel, but difficult to apply. But in place of water, common salt, or another fusible salt, it can be decomposed by the electric current, and we have besides in solid sodium, potassium, magnesium, or calcium, fuels in the solid form, produced with the help of the electric current by natural forces which are already more useful. It is, therefore, no baseless imagination, but a supposition based on quite determined facts, that in this way fuel can be produced by the application of forces existing in nature.

The question of the production of foods is a much more difficult one. These are also essentially fuels. We burn the substance of the food by means of different chemical actions, which occur in our bodies, and thereby supply the heat our life requires. But there is a second condition to be complied with. We must produce or renew the nitrogen combinations of our body. It is, therefore, necessary that the food should contain nitrogen combinations. Nitrogen is a peculiar body, which only enters with difficulty into combination with other substances. It is, therefore, necessary in order to produce food stuffs to arrive at means of getting over the difficulty of combining nitrogen. In organic nature this takes place by means of the life process of plants. In inorganic nature we have only nitric acid and combinations of ammonia, the origin of which is somewhat obscure. Therefore, in fact, my opinion that it would be possible at some future day to produce artificial food which must contain nitrogen would be a dream if a direction, a way did not already exist which gave a prospect of attaining in future the realization of this hypothesis. This means exists in fact. Thirty years ago I described an ozone apparatus in a published treatise. This apparatus consists essentially of two glass tubes, one within the other, the walls of which are at a certain distance from one another, and are provided externally with conducting coverings. If these are connected with a source of electricity which produces alternating currents of high tension, there arises in the space between the glass tubes an appearance of light without the current which produces it penetrating through the insulated space. This electric action taking place in the air space has the property of producing ozone in it; ozone is a modification of oxygen which constitutes its so-called

active state, in which it combines with much greater energy with other bodies. This active oxygen has the property of combining directly with the nitrogen of the air on its production with the co-operation of the electric phenomenon. The so-called sulphur smell, which occurs with every lightning flash, is produced by a combination of nitrogen with oxygen, which arises from the flash traversing the air. That the electric current has the property of combining these materials together is therefore a well-known fact. In the ozone apparatus we have therefore obtained mechanical means for the production of these combinations. This may be considered as a door opening into a futurity, in which, with the assistance of mechanically produced electricity, we can produce commercial nitrogen combinations. It is merely a thing of ordinary scientific technical advance to arrive at the production of nitrogenous bodies by a combination of chemistry with electrical science. In the same way hydrogen is produced in the so-called active condition in the ozone apparatus. It is, therefore, possible to produce mechanically in the future products belonging to the series of ammonia combinations. Whether electro-chemistry will indeed solve the problem of so combining the substances necessary for nourishment that the animal body can assimilate them, and can make use of them as food, lies in the future. Anyway, my opinion is no dream, but an hypothesis, resting on a strong scientific basis. This I wished to say, in justification of myself, for I should not like to allow the reproach to rest on me that they were dreams which have no basis.

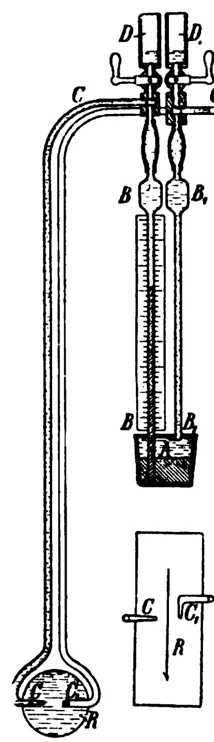
IMPROVEMENTS IN CONTRIVANCES FOR THE CONTINUOUS MEASUREMENT OF THE SPEED OF SHIPS.*

ENDEAVOURS have often been made to measure the speed of ships by the pressure which a current of water exerts on the open mouth

* 1886.

of a tube opposed to it, whilst this increase of pressure was determined in the interior of the ship by suitable apparatus, and an empirical scale was set up for the speed corresponding to these increases of pressure. Endeavours have also been made to measure this speed in a similar manner by the sucking action which a current of water which passes across the mouth of an open tube exerts on the fluid mass contained within the tube.

Fig. 190.



These experiments have, however, failed, principally from two causes: one, namely, that the hydrostatic pressure of the water acting on the mouth of the tube influences the pressure existing in the tube in a similar way as its motion. As the hydrostatic pressure of the water at the tube's mouth is influenced by the burden of the ship, by its pitching, and especially in a high degree by waves, only highly fluctuating and variable indications can be obtained by both methods.

Further, the apparatus for measuring the pressure in the body of the ship had always to be placed below the water-line, by which its practical use would have been much hindered; if the system had not already been rendered impracticable on account of the continual variations in the static pressure of the water.

Our improvements consist in :—

1. That the influence of the hydrostatic pressure of the water on the indications of the instrument is entirely removed.

2. That the pressure-measuring instrument can be placed in the ship up to 10 metres above the level of the water.

A short, wide, and thin walled tube R, the axis of which is parallel to the ship's axis, is placed under or alongside the body of the ship. This thin walled tube offers only a very slight resistance to the motion of the water parallel to its axis with the movement of the ship, so that the horizontal component of the

velocity of the water in the middle of the tube and outside of it are nearly equal. On the other hand, the walls of the tube prevent the measurements being vitiated through vertical differences of velocity. In this wide tube two thin tubes CC_1 are fixed, which enter the body of the ship and pass through it to the place where the speed is to be observed. The lower ends of these two tubes CC_1 pass from the opposite sides, or from the opposite open sections of the tube R, up to the middle of the tube, and are there so bent that the current of water passing through the tube flows past the end of one tube parallel to its mouth, whilst the opening of the other tube is averted from the current of water. The openings of the two tubes are so arranged that they lie in the same section of the outer wide tube, and are at the same distance from its axis.

As the same hydrostatic pressure exists everywhere in the same section of the tube, in this way the influence of the variations of this pressure on the results of the instrument are quite balanced. But the current of water traversing the wide tube exerts a sucking action on both ends of the tube, which, according to exact measurements, is proportional to the square of the velocity. This sucking action is about five times as great in the tube placed sideways, past the mouth of which the water flows, as in that of which the mouth is turned away from the current of water. Therefore there arises in an instrument which measures inside the ship the difference of the two sucking actions, a difference of pressure which is nearly proportional to the square of the velocity of the ship. Different arrangements can be used for the measurement of this difference of pressure; but we prefer to employ a mercury manometer for the purpose, fixed to a universal joint, so as to secure the vertical position of the manometer tube, notwithstanding the motions of the ship.

The suspension of the two communicating tubes BB, lying near to one another, is effected by means of india-rubber tubes, which communicate with the thin lead tubes CC_1, which lead to the wide tube below the ship. At all times the whole system can be filled with water free from air by means of the enlarged open tubes, DD_1, provided with a cock, and connected by india-rubber tubes, if the greatest height above the level of the water does not exceed 10 metres. One of the manometer tubes passes to the bottom of the vessel A half-filled with mercury, whilst the other ends close

under the upper cover of the vessel. If the manometer tube B communicates with the stronger suction mouth, the manometer tube B_1 with the weaker, the mercury must rise in the tube B until the balance of pressure is thereby again established. The speed of the ship is, therefore, proportional to the square root of the rise of the mercury, and can be read by means of a scale calculated in advance. It may be remarked that the readings are the more exact, the greater the ship's speed.

ON A NEW ANEMOMETER.*

In the exhibition of scientific instruments, arranged at Berlin, in honour of the 59th meeting of the German natural philosophers and physicians, amongst the numerous measuring instruments sent to the exhibition by the firm of Siemens & Halske, of Berlin, was an anemometer, brought out by Werner Siemens, which depends on a principle not previously used. In this the phenomenon of suction is used for the measurement of the velocity of wind, and yet more, by means of this apparatus, the mean velocity of the wind during a determined time can be registered, and also the direction of the wind can be determined which exists at each moment.

The apparatus (Fig. 191) is of the following kind :—A measuring cylinder C, divided into cubic centimetres, is closed above airtight by means of a metal plate D ; the latter has two openings, into one of which is fixed a brass tube S with a fine projecting point ; in the other is fixed a syphon bent twice at right angles, which is provided with brass springs on the limb reaching into the cylinder, which holds a small glass beaker B with a mouth-piece ; the other limb dips into a large vessel G, filled with petroleum, the level of which is maintained constant in this way, that petroleum passes constantly into it from a vessel with a fine opening placed

* (Communicated by Dr. Kœpsel in the Zeitschrift für Instrumentkunde, Vol. 7, p. 14. 1886.)

above it, the overflow of which drops off. This arrangement proves itself more suitable than Mariotte's vessel, with which it was not

Fig. 191.

possible to maintain a constant level on account of the capillary force attending the formation of bubbles.

Petroleum was used for this purpose, because it drops out more easily than water and evaporates less easily than other perhaps equally suitable liquids.

The fine point S is connected through a side tube K by means of india-rubber tubing with a manometer M, of which the tube *r* has only a slight inclination from the horizontal; a wide vessel *m* is fused to it below, and is filled with coloured petroleum; a piston *k* immersed in this latter serves to regulate the zero point.

When the apparatus is to be set to work, then, in the first instance, the air in the cylinder C is rarefied by sucking, in consequence of which the small glass beaker within is filled. Now the level of the latter is so arranged by adjusting the outer vessel G that the least rarefaction of the air in the cylinder causes the liquid to drop out of it. If then a current of air is directed sideways over it by means of a tube L arranged at right angles to the point, the liquid falls in consequence of the rarefaction of air brought about by this means in the cylinders from the mouth-piece of the glass beaker B into the cylinder, and the amount of the liquid which falls is a measure of the mean velocity of the air. If in place of a wide syphon a capillary tube were used to join the two basins, the amount of the liquid which dropped would not be proportional to the mean velocity of the wind, but to the sum of the wind energy.

By the rarefaction of the air the liquid rises simultaneously in the manometer tube *r* up to a determined height, which, when equilibrium takes place, serves to read off directly the velocity of the wind on a scale increasing as the square.

The apparatus for determining the direction of the wind consists of four tubes *n*, *s*, *o*, *w*, bent at right angles to one another, the openings of which are directed to the four points of the compass; each opposite pair is connected by means of india-rubber tubing with the openings *a′e′*, *a″ e″* of two manometers M′, M″, like the one described above. The zero of this manometer lies in the middle of the tubes *r′ r″*, and the four ends of the scale are marked with the initials of the four points of the compass. Then if the wind blows in the direction towards which one of these openings points, an increase of pressure of the air will take place in this, and in the opposite one a rarefaction. The first acts on the one side, the other on the other side of a manometer;

the column of liquid will, therefore, be moved from the zero by suitable connection, towards the side which is indicated by the letter which represents the direction from which the wind blows. As the current of air passes with similar velocity in front of two other openings, each of which differs from this direction by 90°, it causes two equal rarefactions which affect both ends of the other manometer, in consequence of which its zero point is unaffected. As a simple consideration shows, the apparatus also gives the intermediate directions by a greater or less movement of the columns of liquid in both manometers. For demonstration this instrument is provided with a rotatable conducting tube L′ with a broad opening for the wind, which equally with the tube L of the registering apparatus would be omitted when the apparatus is used for meteorological purposes.

Finally, it must be mentioned that Prof. v. Bezold first made the proposal to register the strength of the wind by dropping liquid, and that with this apparatus the first attempt has been made to carry out his proposal.

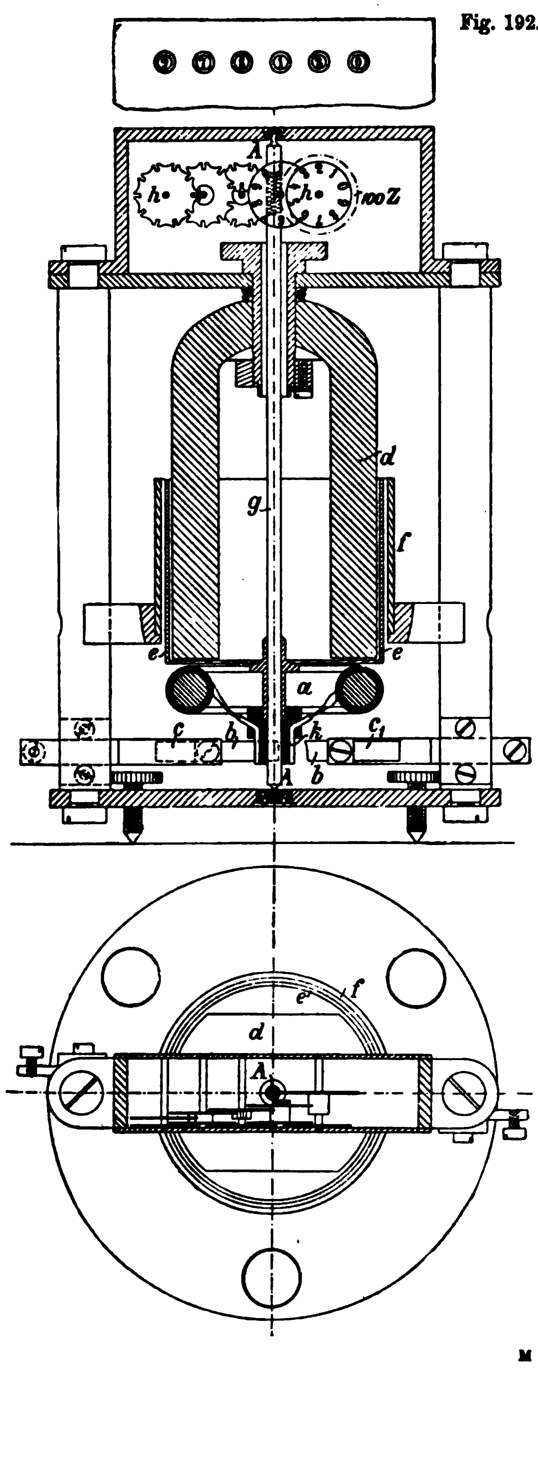
IMPROVEMENTS IN ELECTRICITY METERS.*

THE apparatus used for the measurement of the quantity of electricity passing through a conductor consists essentially of a small magneto or dynamo electric machine acting as a motor, of a damping arrangement connected with the motor, and a counter coupled with the axis of rotation of the motor, which shows the quantity of electricity passing through the conductor in ampère hours, or other measure.

1. The construction of the motor may be seen in Fig. 192; *d* is a horse-shoe magnet, or a system of suitably-shaped polarized or electro magnets; *a* is a so-called Pacinotti ring serving as armature, which is fixed together with the commutator *k* on the spindle *g* turning in the bearings AA. In place of a Pacinotti

* German Patent No. 40,632 of 20th Nov. 1886.

Fig. 192.



ring an armature of any other desired construction, as, for instance, a von Hefner drum, can be used. On the commutator *k* the brushes *bb* slide, which are connected to the conductor with or without a shunt.

2. The damping contrivance consists of a hollow copper cylinder *ee* fixed on the spindle *g* of the armature, the method of action of which is the following. By the rotation of the armature *a*, electric currents are induced in the copper cylinder, which rotates with the same velocity as the armature in the magnetic field of the magnet *d*, these currents tend to make the copper cylinder, and with it the armature *a*, fixed on the same axle, turn in opposite directions. These induction currents, the strength of which is proportional to the distance traversed in a minute of time, or, in other words, to the velocity of rotation, therefore retard the speed of the armature proportional to the velocity. As, further, the moment of inertia communicated to the armature from the current to be measured (with constant magnetism of the magnets *d*) is proportional to the strength of the current, there is equilibrium of motion when the moment of inertia is equal to the retardation, that is when the strength of the current is proportional to the velocity of rotation. The measurement of the strength of the current is, therefore, reduced in a simple manner to the measurement of a length. This result is however modified in practice on account of the friction of the bearings.

The influence of this mechanical, and, therefore, variable friction, which can be made small by appropriate construction, can be made indefinitely small by making the controlling force by electrical retardation very great, so that the velocity of rotation of the Pacinotti ring is very small. This is effected by means of the concentric iron ring *f*, by which the magnetic field in which the copper cylinder turns is rendered very powerful.

The counter which shows the distance traversed by the Pacinotti ring in a certain interval of time by the number of revolutions made is of any usual construction, and is coupled in any known manner with the axis of rotation of the armature.

The inventors attach less importance to the construction of this portion of the current apparatus and of the motor than to the electric brake described. As compared with mechanical brakes which have hitherto been used in the electric motors employed in

current *measuring* apparatus, and which necessitate special mechanism for regulating the brake as regards the velocity (see German Patent 20,828, and English specification 2675, of 1883) the electric brake has the advantage of greater simplicity. As, further, the electric brake follows a most simple law, and is independent of the action of any other mechanism, by its means a simplicity and security in the reading of the apparatus can be assured, impossible with the help of mechanical brakes. Attention should also be drawn to the circumstance, that with a constant strength of the current to be measured, both the electric brake and also the moment of inertia of the armature is proportional to the strength of the magnetic field ; that, therefore, the velocity of the armature, and consequently also the reading of the apparatus, is independent within certain limits of the strength of the magnet *d*. Finally, as the commutator-brushes are approached to the neutral line of the armature, or as the magnet is turned in the opposite direction with a fixed position of the brushes, the moment of rotation of the armature diminishes with a constant strength of current to be measured, whilst the electric brake continues uniform. In this way we are in possession of a very simple means to settle correctly the constant of the counter for the electrical measurement of the currents to be measured, and, therefore, to adjust the apparatus to different strengths of current.

If the polarized magnet is replaced by an electro-magnet, or a system of electro-magnets, the windings of the latter are to be connected up in a shunt to the two conductors supplying the place where current is consumed, so that the electro-magnets are traversed by a current due to potential difference, whilst the windings of the armatures are traversed by a part proportional to the main current.

Instead of the armature the magnet, or the electro-magnet, can be rotated, and the armature and the electric brake be fixed. Finally, two systems of magnets, or electro-magnets, can be used (one system as magnetic field for the armature *a*, and the other as magnetic field for the electric brake).

PATENT CLAIM.

In electric counters, which employ as the working force the moment of inertia of a magnetic field exerted on a moving

conductor, the use of an electric brake in connection with the moving conductor, strengthened by surrounding the magnetic field with a closed iron mantle, which effects a retardation proportional to the velocity of rotation ; so that the path traversed by the moving conductor in the unit of time, and communicated to the counter, is proportional to the strength of current to be measured passing through the moving conductor.

ON ELECTRIC METERS FOR SUPPLY STATIONS.*

THE difficulties of all kinds encountered in the arrangement and carrying out of small electric lighting installations in great towns necessitate the formation of large central stations for the production of electric current and of a network of conductors for its distribution, in the same way as gas and water are carried to houses by means of distributing pipes. It is only by means of such central supplies, from which everyone can obtain the desired electric current for illumination, for the production of power, and for other purposes, without further difficulties against payment for the current consumed, that electricity is in a position to render the greatest possible service to mankind to which it is called. Such central stations, which are fitted with the necessary reserves and technical safeguards of all kinds, assure to electric lighting and transmission of power that security and certainty which is necessary in order to obtain the full confidence of the consuming public. Besides, large motors and electric apparatus work much more economically than small, and the cost of production of electricity to be supplied to consumers is, therefore, with well-arranged central stations, much smaller than with individual installations, notwithstanding the loss of power due to the resistance of the current distributing network. One of the greatest services which Edison has rendered to the extension of the means of electric lighting is, that he not only, without doubt, first brought the incandescence lamp into a serviceable form, but first planned

* Address to the Electrotechnic Society, 24th May, 1887.

electric central stations, and carried them out practically. For establishing these central stations the construction of a measuring instrument was essential, which continuously registered the consumption of electric energy by each consumer. Edison has constructed several such measuring instruments, some of which effect their object very satisfactorily. After him a number of inventors have been engaged on the problem, and there is now quite a series of more or less suitable electrical registering apparatus for central stations. These can be divided into two groups, namely, energy meters and current meters. The theoretical problem is exactly solved only by the first group, as only the sum of the electric energy required by the consumer, *i.e.*, the product of electric tension (*e*), strength of current (*i*), and the time during which the consumption takes place (*t*), corresponds to the actual value of the electric supply.

In central stations it is, however, a necessary condition that the electric potential of the current generated should always remain constant, and it is the problem of the electrical engineer, if possible, so to combine the network of conductors that the current supplied to the consumers has everywhere nearly the same electric potential. The potential (*e*) is, therefore, to be assumed as a constant factor for the supply in question, and it is sufficient to arrange the instruments so that they continuously measure and sum-up the product *i.t.* only.

The simplest method of measuring and summing-up the product *i.t.* is that already proposed by Edison, and practically carried out with success, viz., the electrolytic. As, indeed, electrolytic solution, like the deposit of a metal, is proportional to the quantity of electricity passed between the electrodes, therefore, also, to the sum of the product *i.t.*, it suffices to fix the weight of the anode or cathode of an electrolytic cell, in order to determine by the difference of weights the quantity of electricity consumed between two weighings.

This, the simplest electricity meter which can be imagined, acts with perfect certainty and sufficient accuracy when dimensions are given to it, large enough to allow the whole maximum current to be measured to traverse it. As this, however, leads to inconveniently large dimensions of the cells, usually only a portion of the current is allowed to pass through the apparatus. In this

way, however, the measurement loses its exactness, as one branch of the current is formed of a metallic, the other of an electrolytic resistance, and as the resistance of the electrolyte varies in an opposite way with alteration of temperature from that of the metal. In addition to this, the reduction of the specific resistance of the electrolyte takes place in very quick progression with increase of temperature. The consequent dependence of the results of the electrolytic electricity meter on the temperature of the cell appears to render its application hardly permissible, if the whole of the current to be controlled is not passed through the meter.

Another method also proposed by Edison for the measurement of electricity consists in allowing the current subjected to the control measurement, or a portion of it, to pass through the windings of a small electro-magnetic machine, which has to perform a work proportional to its velocity of rotation. If this performance of work is so great that the velocity of rotation of the machine is very considerably reduced by it, that the internal friction of the machine may be considered as negligibly small in comparison with its external performance of work, then the velocity of rotation within certain limits is a measure of the strength of current, and the number of revolutions shown by a counter a measure of the quantity of electricity which traversed the conductor. Besides Edison, many other constructors have proposed electric meters on this system for electricity supply stations, from which, however, hitherto no very satisfactory results have been obtained. The reason of this has been, that the resistance which liquids oppose to the motion of solid bodies, increases not directly as the velocity, but in a higher proportion.

I pass over many constructions of electricity and energy-meters, which, although theoretically correct, are too complicated or delicate to be able to be used as practically serviceable measuring-instruments, and will only here refer to two apparatus which within certain limits have appeared serviceable. These are the electricity meters of Ferranti and Dr. Aron.

Ferranti's meter* depends on the circumstance that mercury which surrounds a magnetic pole is set in rotation round it when it is traversed by radial currents. Ferranti measures this velocity of

* Electrotechn. Zeitschrift, Vol. 7, p. 65.

rotation of the mercury by a light lever dipping into the mercury and pivotted concentrically with its rotation, the revolutions of which are registered by means of a counter. This apparatus gives satisfactory results, when well regulated, and when the resistance of the rotating lever and of the counter is exceedingly small. It is, however, to be feared that, owing to the extraordinarily weak unipolar force of rotation, and the consequently extraordinary delicacy of all the moving parts, as well as owing to the alterations which the mobility of the mercury experiences with continuous contact with solid metals and with the air, this system will not keep in continuous practical use.

The electricity meter constructed by our member, Dr. Aron, appears to have given satisfactory results throughout. As you will remember, from his address,* it depends on the fact, that the time of oscillation of the pendulum diminishes as the square root of the attractive forces acting upon it. With a small increase in the attractive force, the decrease in the time of oscillation may be taken as proportional to the said increase without perceptible error. Dr. Aron employs a steel magnet as the pendulum weight, and allows the whole of the current to be measured to pass through a coil of wire, which is placed vertically below the plumb-line of the pendulum. If the pendulum is connected to a regularly-going clock, the difference in time between this clock and a standard one is a measure of the quantity of electricity which has traversed the coil of wire. The objection that the consumer cannot himself at all times observe and control his consumption of current, Dr. Aron has lately sought to overcome, by using two clocks for each electricity meter, which are connected by means of differential mechanism in such a way that a counter shows continuously the difference between the rate of the accelerated and the standard clock.

It must be acknowledged as a drawback to this well-arranged system for the continuous measurement of currents, that the limits of the strength of current which can be registered by one apparatus without error lie very close together. This is especially very disturbing when the consumption of electricity varies within wide limits, as is frequently the case.

* Electrotechn. Zeitschrift, Vol. 5, pp. 480 *et seq.*

The electricity meter placed before you is a further development of the system of an electro-magnetic machine with the performance of work proportional to the velocity of rotation. This performance of work is in this case electro-dynamic, which within wide limits is exactly proportional to the velocity of rotation of the machine.

The apparatus consists essentially of a small Pacinotti ring with vertical axis, to which is attached a commutator of very small diameter, formed of platinum wires. The ring is surrounded with a copper cylinder, and firmly fixed concentrically with it. A horse-shoe magnet of glass-hardened tungsten steel projects with its polar ends within the copper cylinder, so that they are nearly opposite to the ring, without however touching the ring and copper covering. The copper cylinder rotating with the ring is itself surrounded by a fixed iron ring. If a current traverses the windings of the ring, the copper cylinder rotates with it between the poles of the steel magnet and the iron cylinder surrounding it, by which currents of great strength are induced in it, proportional throughout to the velocity of rotation, which reduce the velocity of rotation by about $\frac{1}{20}$th the amount which it would have without the electro-dynamic damping. As the weight of the rotating portion of the apparatus rests upon a point, and is considerably reduced by the attraction between the magnet-poles and the iron ring, and as further the commutator has a very small diameter, and is only lightly touched by the fixed conducting-wires, the ring even with very slight currents is set in regular slow rotation, which is quite proportional to the strength of the current within wide limits. A simple counter of the rotations, the dial of which is always visible through the glass cover of the cylindrical case of the apparatus, gives at all times with exactness the quantity of electricity expended. The adjustment of the correct velocity of rotation for the registration of the current can easily be effected by a small shunt enclosed within the apparatus, or by the rotation of the steel magnet, whereby no visible sparking at the commutator arises. The circumstance, that the same steel magnet which causes the rotation of the ring exactly proportional to the strength of the current also effects the electro-dynamic damping, makes the rotation tolerably independent of variations in the strength of the permanent magnetism. If, therefore, long use of

the apparatus should actually lead to a weakening of the steel magnet, this would remain without essential influence upon the measurement of the current. The velocity of rotation of the apparatus may increase without injurious heating of the windings and copper cylinder, and without the formation of sparks at the commutator from about 7 to 150 revolutions a minute, without the proportionality with strength of current altering. The apparatus is, therefore, applicable with suitable current derivation for an installation of 30 to 40 incandescence lamps, when the consumption of current by a single lamp has still to be registered. If a greater range of measurement is desired, this can be effected by a combination of two similar meters. If the division of the current is so arranged that the branch resistance of the main current in the second instrument is only $\frac{1}{10}$th as great as that of the first, only a tenth of the current traverses the second which traverses the first; the readings of its counter have, therefore, twofold value. By a simple automatic switch, instead of the whole branch resistance of the main current, one can insert with the second apparatus $\frac{1}{10}$th of it, if the strength of the current exceeds a certain limit. In this way the extent of the measurement can be increased tenfold without exceeding the lower limit. Of course, the readings of the two meters must be added in order to determine the consumption of electricity.

APPARATUS FOR MEASURING AND ADDING UP THE ENERGY PASSING THROUGH A CONDUCTOR WITH CONTINUOUS OR ALTERNATING CURRENTS.*

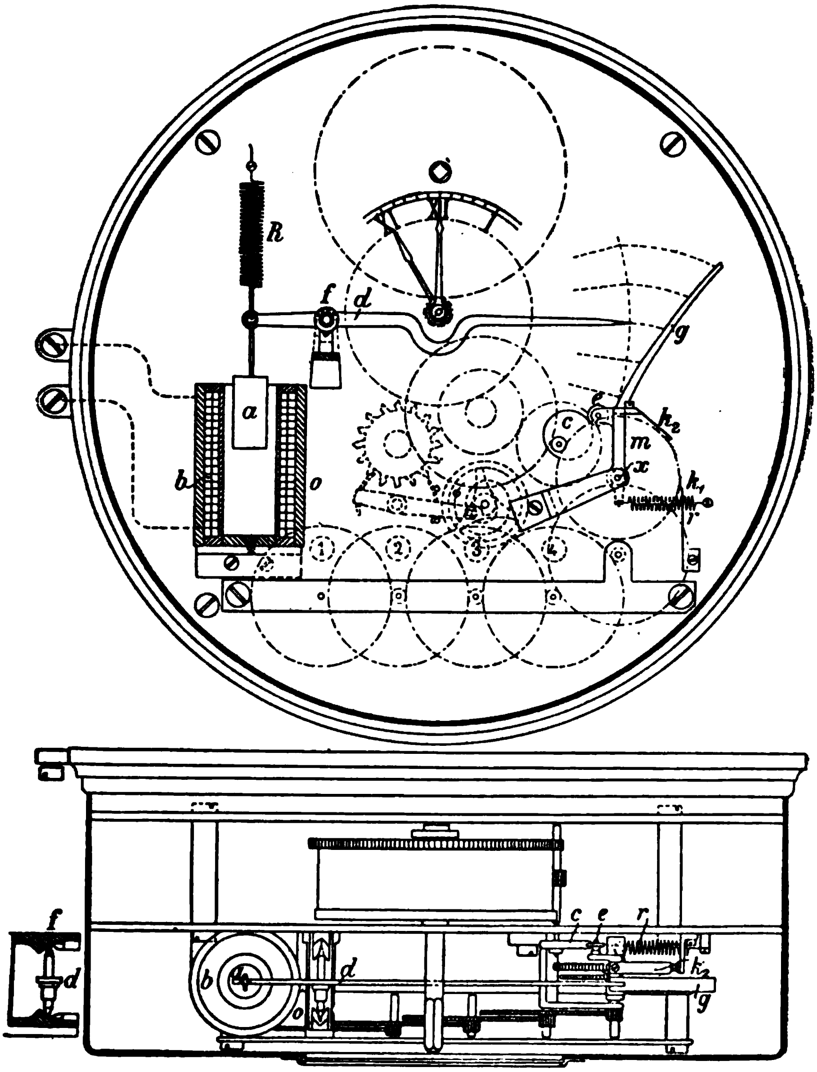
THE energy-meters forming the subject of the present invention are based on the method already employed in patent No. 25,919, of continuously measuring the product of the strength and poten-

* German Patent, No. 50,623 of 8th Feb. 1889.

tial of the current traversing the conductor at determined regular intervals, and of totalizing the same by means of a counter, on the supposition that the indications given by the counter correspond without material error with the actual consumption of electric energy. The arrangement here described differs essentially from the above-mentioned measuring apparatus, depending upon the same principle in that the current to be registered has no other work to perform than the movement of a pointer, that the consumption of energy in the meter itself is consequently exceedingly small, and the difference of the currents to be measured by the same apparatus can therefore be very great. Whether the apparatus measures the energy consumed, or the sum of the current strengths, viz., the quantity of electricity consumed depends only on whether the position of the pointer is made dependent on the magnitude of the product of the tension and strength of current (S × J), or on the strength of the current J alone. As in central stations the pressure is always maintained constant, and it is for these stations alone that registering apparatus of this kind are necessary, in the following description only the measurement of the quantity of electricity is kept in view.

The apparatus constructed in two forms, which are represented in Figs. 193 and 194, consists essentially of a light suitably-bent lever *g*, which is moved by clockwork from its position of rest at fixed intervals of time, for instance, every five minutes, against the point or edge of a pointer *d* until the lever strikes the latter, and that the angle of rotation—described each time by the lever by this motion—is transferred to a toothed wheel placed on the axis of the lever, and through this to the counter. If, now, the position of the pointer *d* is brought into a fixed relation to the strength of the current to be registered, and if the curve which bounds the lever on the side which is opposite to the end of the pointer is so shaped that the angles of arc, which the lever must traverse, until it touches the pointer are proportional to the strengths of current, which correspond to these positions of the pointer, the counter will totalize all the current strengths which existed at the time of measurement, and measures consequently the quantity of electricity passed through the conductor, on the supposition that the separate measurements may be taken as the mean current strengths, which will be pretty nearly the case with

Fig. 193.



continuous working if the intervals of measurement are not too widely separated.

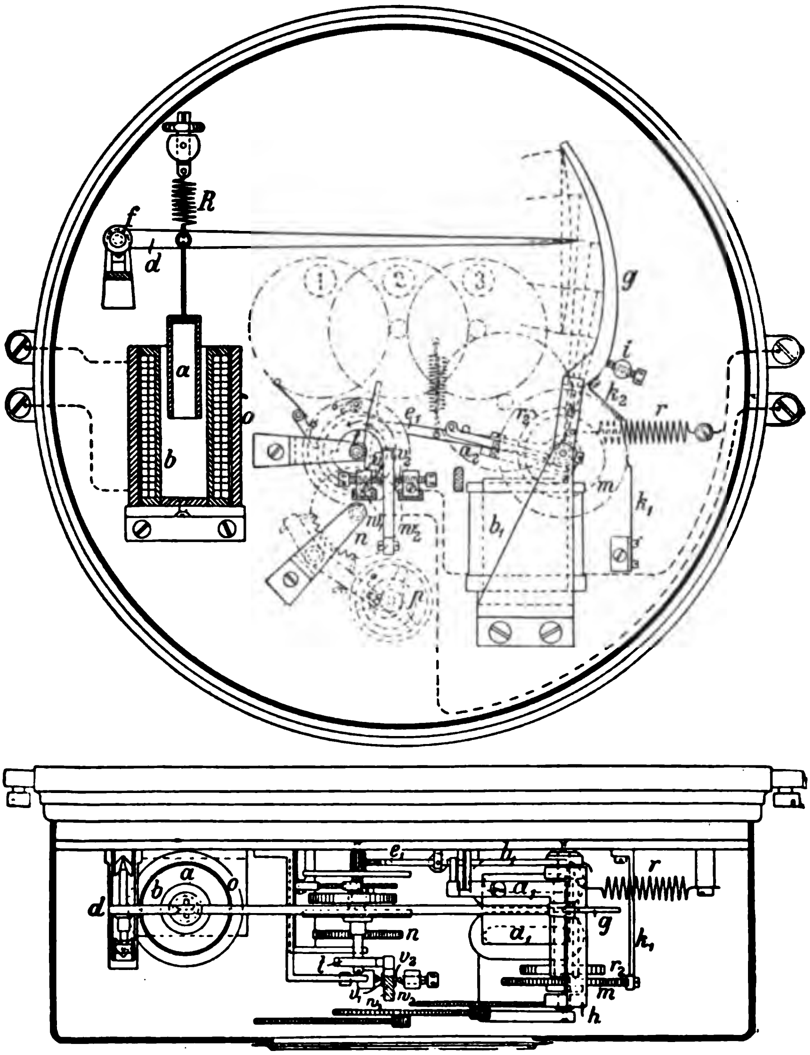
The two modifications of the apparatus, represented in the

figures, only differ materially in that in the apparatus shown in Fig. 193, the motion of the lever *g*, by means of which the measurement is carried out, is effected by an eccentric disc, which is rotated regularly by means of clockwork wound up by hand, whilst as regards the apparatus represented in Fig. 194 the motion of the lever is effected by an electro-magnet the windings of which are traversed by a short current at determined intervals of time by means of an automatic contact device.

In the apparatus shown in Fig. 193, *d* represents the pointer pivoted at *f*, at the short end of which a magnet *a*, which is carried by the adjustable spiral spring R, hangs in a solenoid. This spring is so adjusted that the edge of the long arm of the pointer is opposite the lowest point of the division of the lever *g*, without actually touching the latter, whilst this edge, with the strongest current which the apparatus is arranged to register, is opposite to the highest point of the division, so that this division touches the edge, when the lever is turned, until it is prevented by touching the edge from further rotation. This angle of motion forms the measure of the highest possible strength of current for which the counter is constructed. The curvature of the narrow surface of the lever *g* presented to the edge of the pointer *d* is so chosen that also at all intermediate values of the current strength, and the consequent positions of the edge of the pointer dependent on the latter, the angular motion of the lever *g* is proportional to the strength of the current. This gives the great advantage that it is unnecessary to arrange the magnet system in such a way that the rotation of the pointer is proportional to the strength of the current, or generally has a determined ratio to it. It is sufficient empirically to arrange the curvature of the lever *g*, so that the proportionality of the angle of rotation of this lever to the strength of the current at every moment is always maintained. If by a change of magnetism or from other causes a change in the position of the pointer becomes necessary, it suffices to adjust the pointer by means of the spring R, for a single strength in order to make the readings of all strengths of current again correct.

For transmitting the angle of rotation of the lever *g* to the counter, a loose ratchet-wheel, *m*, is placed on the axis of rotation *x* of the lever which is connected by means of a pinion and spur-wheel with the counter. On the lever *g* is placed a spring

Fig. 194.



pawl k_2, by which the wheel is always turned forward proportionately to the turning of the lever. The fixed spring pawl k_1 prevents the turning back of the wheel. The lever g itself is moved by

the spiral spring against the edge of the pointer, whilst the eccentric disc *c* turned by the clockwork by means of the roller *e* fixed to the lever presses this back into the position of rest once in each revolution, thereby stretching the spring *r*.

In order that the pointer may move as much as possible without friction, and yet be firmly pivoted, the hardened steel points of the spindle of the pointer are supported in glass-hardened circular steel channels, as is shewn in detail to the left of Fig. 193 near the section. As the points are somewhat more acute angled than the grooves, only the outermost points rest on the base of the grooves. In order to secure the horizontal position of the axle, steel pieces filling up the grooves are cut obliquely and pushed in until they touch the points of the pivotted axis and then fixed. The axis is then fixed without touching at any other parts than the outermost points.

To get rid of the inconvenience of repeatedly winding up the clockwork, and the necessity for the use of large powerful clockwork, an inconvenience which is specially felt in places where there is only a small consumption of electricity, the construction represented in Fig. 194 is intended.

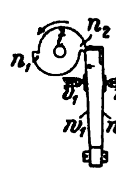
The pointer *d* is in this case arranged as a one-armed lever, so that the position of rest of the pointer, when no current passes, lies at the outermost end of the oscillating lever *g*. This arrangement has the advantage that very weak currents can be more exactly registered, as considerable angular displacements of the pointer *d* correspond to small angular rotation at the outer end of the lever *g*. In this modification the measuring lever *g* is drawn by the spring *r* against a fixed stop *i*, which is so regulated that when no current is passing the edge of the pointer *d* is opposite to the outermost division of the curve of the lever *g*, without any contact taking place.

The rotation of the lever *g* against the edge of the pointer *d* is in this case effected by means of a small band magnet *b* with fine wire windings by means of the armature plate a_2. This iron plate rests loose on the axle of the lever *g*, with which it is, however, connected by means of the spring r_2. When the armature is attracted the lever *g* is softly pressed by the spring r_2 against the edge of the pointer *d*, and held against the latter until the magnetization has ceased, when the spring *r* again attains the ascendancy.

and brings back the lever g to the stop i. The windings of the electro-magnet b_1 are inserted in a shunt circuit of very high resistance; the magnet is, therefore, always uniformly excited if the circuit is completed. This can be effected in any way whereby a short current is produced at regularly recurring intervals of time. In the apparatus shown in Fig. 194 this is effected by means of clockwork with anchor escapement, which has besides the balance p and the escapement-wheel n only a driving barrel with a spring, which is wound up on each attraction of the armature a_2 by the toothed sector e_1 connected with the magnetic armature a_2 so much as is necessary to enable the clockwork to be kept in motion until the next attraction.

To produce the short current through the magnet windings a contact arrangement is used, which is specially represented in Fig. 195. On the spindle of the spring barrel is fixed a disc with two concentrically rising and vertically falling projections n_1 n_2, on which slide the ends of two springs w_1 and w_2 until these have passed a projection, and then fall down. The two springs are in metallic connection. The conductive connection between the two contact screws v_1 and v_2 is, therefore, formed when both springs are in contact with their corresponding contact screws. This is, however, only the case so long as one spring w_1 has fallen off, whilst the other has not yet passed the nose, and is pressed by the latter against the contact v_2. This arrangement has the advantage, that the contact, and with it the current, is suddenly closed and broken, and that, therefore, neither on breaking nor on closing can an undecided contact take place, which by concussions could produce a clatter, and in this way false indications.

Fig. 195.



In order to prevent the instrument being affected by strong magnets brought near it, the solenoid b can be surrounded with an iron casing o.

If the instruments described are to be used not for the measurement of electricity, but for the measurement of electric energy in circuits, in which the electric potential undergoes decided variations, instead of a steel or iron core a solenoid with windings of fine wire can be hung in the fixed solenoid, and the pointer can be fixed to the former. In this case, however, it is preferable to

make use of the form used in electro-dynamometers of a rotative solenoid within a fixed one.

In Fig. 196 the arrangement of this rotating solenoid with the pointer attached to it is shown in plan and vertical section, and the other portions of the apparatus which remain exactly like those previously described are omitted from the drawing. Between the fixed solenoids SS_1 divided into two parts is the rotatable solenoid S_2 with windings of fine wire which run in a plane at right angles to the windings of the fixed solenoid first named. The moveable solenoid S_2 is fixed on an axle *f*, to which the pointer *d* is fastened. The axle *f* of the moveable solenoid S_2 serves at the same time to lead the current to this solenoid; this construction can be carried out in various different ways. In the arrangement shown in the

Fig. 196.

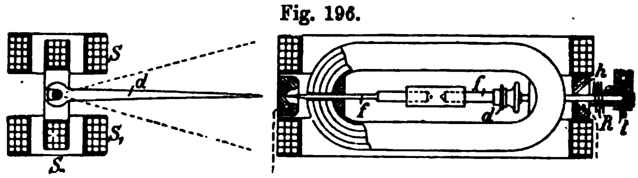


figure for example, the lower point of the axle *f* turns in a mercury cup, into which one leading wire dips, whilst the upper part of this axle *f*, the upper point of which again runs in a suitable bearing, passes through a vessel *h* of glass, stone, or other material which cannot be amalgamated, which is filled with mercury, and receives the second conducting wire. The hole in the vessel *h*, through which the axle *f* passes, is so dimensioned that there is only the very smallest clearance between the axle and the wall of the boring, so that the mercury, in consequence of capillary attraction, is prevented from passing out of the glass vessel.

By means of a spiral spring R, which can be turned by means of the knob *l*, the position of rest of the rotatable solenoid is adjusted, whilst the torsion strength of the spring is so calculated that the pointer completely traverses the scale of the oscillating lever with the greatest energy to be measured.

The oscillating lever *g*, not shown here, which is periodically brought from its position of rest to strike against the pointer *d*, is provided in this case also with a curvature on the side turned to

the pointer, so formed that the angles of rotation, which the oscillating lever describes up to its contact with the pointer, are proportional to the amount to be measured—therefore to the product of the tension and strength of current, so that in consequence the counter gives directly the energy consumed.

PATENT CLAIMS.

In an apparatus for measuring and totalizing electric energy, in which are summed up the angles of rotation of a properly arranged lever, which is turned at fixed intervals of time until it touches a pointer determined in its position by the electric energy passing at the time.

1. The arrangement of an eccentric disc which is continually turned by clockwork, whilst a spring brings the lever which describes the angles to be totalized on the return of the eccentric without shock against the edge of the pointer, which prevents the further turning of this lever.

2. The substitution for the eccentric disc continually turned by clockwork, and causing the motion of the oscillating lever of the arrangement of an electro-magnet or solenoid, the windings of which lie in the shunt to the conductor, by which simultaneously the clockwork producing the periodic contact is wound up.

3. For the purpose of suddenly making and breaking the periodic contacts mentioned under 2, the arrangement of two springs in conductive connection with each other, which are raised by the clockwork and fall shortly after one another, whereby the falling of the first spring makes, and of the second breaks, the contact.

ON UNDERGROUND CONDUCTORS IN ELECTRIC INSTALLATIONS.*

GENTLEMEN,—The well-known English electrical engineer, Prof. George Forbes, on the 28th of last month, brought a com-

* (Paper before the Electrotechnic Society on 26th March, 1889.)

munication before the English Institution of Electrical Engineers, on the "Electric light central stations of Europe and what they teach," in the introduction to which he apologetically remarks that even in England much can be learnt from those who were in the position to collect experience in this direction earlier than the English. Prof. Forbes has in the journey which he has made through Berlin, Milan and Rome learnt much which he willingly recognises as an advance in this province. That this has itself surprised him follows from the expression, that to his astonishment in the Berlin Central Station, which was very methodically and effectively arranged, he had only come across German work, at least he had certainly not seen any American. In Berlin, the birthplace of underground lines, of the dynamo machine, of electric railways, and numberless other electrotechnical acquisitions, this surprise seems somewhat astonishing. Prof. Forbes and his countrymen will have to accustom themselves to the thought, that the times are passed when the superior English science alone ruled the world, and that also outside of England's encircling and protecting sea, genuine technical productions are to be found. Prof. Forbes says in the introduction to his address, that he wished to raise a discussion on the details of electric light central stations and networks for current distribution, and to make a protest against faulty systems. He, however, unfortunately immediately begins this useful discussion, without thoroughly informing himself, with a protest against the system of iron-armoured, lead-cased conductors, which he has found in the three towns visited by him. He supports his dogmatic judgment exclusively on the experience which has been arrived at in Berlin on this system of conductors, and thence concludes, that these cables continue very good for three years, and that then in general they go to ruin. The lead was eaten away and the water penetrated to the copper, which was then destroyed. It was presumed that the destruction of the lead came about through its forming a galvanic cell with the iron sheathing. Whatever, however, might be the cause, it is certain that such cables did not last as underground conductors longer than three years. One would think that so eminent an electrical engineer would only give so severely condemnatory an opinion on so widely extended a system on the basis of very thorough study. In Prof. Forbes'

address, however, nothing of this kind is to be found. He supports, as said, his judgment in the first place on the unsatisfactory experience gained in Berlin, for the communication of which he has to thank Messrs. Rathenau & Datterer of the Allgemeine Electricitäts Company, and further on the unsatisfactory experience hitherto gained in England and America with lead covered cables from various sources. In neither of these cases has a lead covered cable lasted more than three years, and likewise the Berlin gentlemen had represented three years as the period when destruction begins.

I must here express the hope that the Berlin electrical engineers in question have been misunderstood by Prof. Forbes, and that they will publicly set this right, as the expressions ascribed to them do not correspond with the facts. In fact the Berlin network of mains which has been manufactured and laid by the firm of Siemens & Halske has a street length of 130,000 metres, of which about 51,700 metres were laid in the year 1885, whilst about 86,400 metres were laid in the years 1887–88. Of these the first portion of the cable laid for about three-and-a-half years is entirely unaltered. Neither oxidation of the lead tube nor break down of the insulation has been noted. The iron sheathing covered with bitumen, and a layer 3mm. thick of tarred jute, has also suffered no alteration, as was proved a short time ago by digging at about thirty places of the Berlin circuit. Failure in the cable network first took place in the month of August of last year, shortly after the electric connection of the three distributing networks was effected, and exclusively in cables of the later layings in the years 1886 and 1887. The occurrence of the faults was unfortunately only announced, at least they were only reported to be wanting repairs, after a complete destruction of the places in question had occurred owing to the melting of neighbouring cables. During the repairs, which were carried out in a few days without any important disturbance of the working, faults were found in four places, and removed by replacing about 200 metres of cable. In this way the insulation of the whole network was again made good, and no new fault has since occurred as the manager, Mr. Rathenau, has lately stated in reply to a direct enquiry. Of the faults which have occurred two, as examination now proves, are due to external injuries—blows with the pick. As

regards the others the destruction due to the melting has extended so far, that the cause of the first fault of insulation can no longer be ascertained. That the iron-strip protection in the portion of the cable close to the faults was partly galvanically corroded, is the natural consequence of the melting together of copper, lead and iron at this spot. The renewal of this piece of cable with corroded iron sheathing, necessitated the disproportionately great length of about 200 metres of cable, required for the repair. Prof. Forbes has overlooked that such a corrosion of the iron by the current in the cable must necessarily happen as a secondary action of the fault which occurred, and erroneously assumes that this disturbance was the first cause of the fault which occurred, and that it was owing to the galvanic difference of potential between lead and iron. That, he says, the lead would be galvanically destroyed by such a contact of lead and iron is evidently an error committed in a hurry, because lead from its position in the potential series is on the contrary prevented from oxidation by contact with iron, and iron on the contrary injured. Such a destruction of the iron would be altogether without influence on the preservation of the lead, and therefore on the insulation of the cable. But after the construction of the cable no contact between lead and iron took place. Both are carefully separated from one another by a layer of asphalted jute 3mm. thick, and their insulation from one another is always tested. It is therefore a mistake of Prof. Forbes that the galvanic difference of potential between lead and iron is the cause of the destruction which occurred of certain short pieces of cable of the Berlin network. This is also confirmed because whenever there has been any digging up, the iron covering which is itself protected by a covering of asphalte, and finally, by a covering of tarred jute about 3mm. thick has shown itself entirely untouched, and usually of exactly the same appearance as before the laying. As already explained, the Berlin cable network, with its many ramifications and house connections, is unfortunately not so laid, that, without great disturbance of the service, regular measurements of insulation of the whole network and its parts can be carried out as may be done with a rational system of working. It is only to be ascribed to this circumstance, to the want of testing of the insulation, that the faults which have occurred could increase so as to become a cause of disturbance.

Unfortunately for these reasons it cannot be ascertained whether the total network has maintained its original high insulation unaltered. It is indeed possible that some faults have already occurred which must first develope themselves before they become evident in use, and can be repaired. That however there is no reason for assuming a general considerable reduction of insulation is shown by the measurements which have been made on cables of similar construction, which have been laid down in other places by Siemens and Halske. Thus the ten cables of similar construction laid down in Munich for lighting the theatre in the year 1884, of about 1,688 metres in length, were tested on the 9th of March of this year, and nine of these cables gave an insulation of about 50 million ohms per kilometre, whilst one cable showed a considerably lower insulation, which nevertheless was still not observed in working. Immediately after laying, these cables had an average insulation of 160 million ohms per kilometre. This practically quite unimportant decrease in the insulation is, however, only apparent, as the cable ends lie in unwarmed damp places, and could not be dried and insulated with the care that the measurement of such high insulation requires. These cables, which have now been in use for five years, show quite convincingly the incorrectness of the assertion of Prof. Forbes that the iron-armoured lead cables only gave three years' service, and then came to an end owing to the destruction of the lead. How completely untenable and groundless is this judgment is, however, seen already from the figures obtained for the Berlin distributing network, for notwithstanding the neglect of the insulation control by which small faults would have been able to develope into extensive disturbances, there is nevertheless only a length of cable of $\frac{1}{8}$th per cent. of the length of the Berlin network that has had to be repaired. It is quite incorrect to draw the conclusion that the iron-armoured lead cables are to be considered a failure. With much greater accuracy this assertion can be opposed by the other, that the results of the use of such cables in the central stations of Berlin, Munich, Rome, Turin, Milan, Mülhausen, Lyons, the Hague, St. Petersburg, Moscow, &c., have given proof that this system has fully succeeded, and anyhow at the present time is the best, safest and most durable of all systems hitherto used of underground conductors for central stations. That faults

due to external injuries, or occurring during construction or laying can arise with it is quite possible. A cable network as well as any other technical installation requires careful supervision, and arrangements must be so carried out that this is easily practicable.

Prof. Forbes gives as a further ground for his general condemnatory judgment pronounced on all lead-cased conductors, that the lead does not keep, especially in the ground, and that in none of the numerous applications in England and America has a greater duration than three years been observed. If this is correct it only proves that in these countries the correct data for the construction, manufacture, and laying of lead cables have not yet been followed. In Germany for a generation past experiments with lead cables have been carried out, and many unfortunate results have been experienced. When the extensive system of conductors insulated with gutta-percha, laid in the years 1847 to 1850 in the ground without other protection, failed owing to external damage, which was generally caused by field-mice, rats, and other gnawing animals, it was sought to protect them externally by means of a covering of lead. But this attempt also failed, because the animals gnawed the lead also. It was, however, shown that the lead, which in general remained quite unimpaired in the ground, so that now after more than forty years lead cables have been dug up which are entirely unaltered, was yet completely destroyed in a short time at some points. The examination of this circumstance proved, that wherever vegetable matter, such as wood or other plant fibre, came into direct contact with the lead, this was quickly converted by the action of the air into carbonate or acetate of lead, whereas in such soil as is free from organic material, it remained unaltered for centuries, as is shown by the remains of the Roman water-pipes which still remain unaltered. Therefore the lead tube must be carefully protected from all contact throughout its length with putrefying vegetable matter, which was the more difficult, as it was shown that even embedding in chalk or cement was prejudicial to the preservation of the lead. It is only a series of experiments extending over years which has led to the knowledge, that an asphalte covering of the lead tube and a subsequent covering of it with a layer of asphalted braiding, such as hemp or jute, formed a perfectly safe dividing layer. This protecting covering of the lead itself required a further protection against external

injury by men and animals. As the drawing in of the thick and only slightly flexible insulated conductors through iron pipes in long stretches is not practicable, whilst the laying of them in iron or brick conduits is costly, and can only be used when the conduits are so wide that men can easily work in them; the protecting means most easily applicable was a wrapping of a double spiral of iron strip which again on its side must be protected against oxidation by being asphalted or galvanized, and by a final serving of tarred jute. Lengthy experiments carried out for years have proved that in this way conductors can be made, which last for an unlimited time in all sorts of soil not strongly impregnated with foul animal substances. It is certainly necessary for the production of perfect insulation, that the braiding which separates the copper strand from the inner wall of the lead tube should be completely saturated with highly insulating material, so that all its pores are filled with an impregnating mass, and that the lead tube itself should be perfectly watertight and free from pores. Unfortunately experience taught us that this could not be surely attained with the ordinary lead tube presses in which the lead is heated to the melting point. Owing to impurities in the lead and small air bubbles, channels were formed here and there through the lead wall, through which water in course of time found its way to the insulator. By a double covering with lead, the time necessary for this was very considerably lengthened, but the evil was not altogether got rid of, as the water, which found its way through a fault in the outer tube to the space between the two lead tubes, spread along in the same, until it arrived at a fault in the inner tube. But we have succeeded in making perfectly tight leaden coverings by pressing the lead in the cold condition around the insulated copper strand by the application of very high pressure. By means of the powerful pressure necessary for this purpose the air bubbles still existing in the ingots of lead are compressed to a harmless minimum, and with the greater thickness that can be given to the lead wall, small solid impurities of the lead cannot easily reach through the whole wall. When this happens it is a question of thorough electric testing to discover and get rid of such faults during the manufacture. In order to do this, and also to be able to discover the first occurrence of faults later on by means of regular electric control of the cable

system, as high an insulation as possible of the cable is necessary, although this is not absolutely essential for practical use.

The objection may be raised against the construction of cable in general carried out by the firm of Siemens & Halske, that asphalted jute as a separating material between the lead and iron strip covering could in the course of time lead to a destruction of the lead tube, that the jute, despite its saturation with asphalte would decay, and give occasion to the formation of carbonate and acetate of lead. This may be taken into account by the use of asbestos instead of jute fibre. But as lengthy experience speaks in favour of the lasting preservation of jute fibre soaked with asphalte, it appears that the use of the costly asbestos fibre may be dispensed with.

It may be further alleged as a disadvantage of the system of leaden conductors described that the double strip iron-covering cannot be made strong enough fully to guard against injuries by workmen's tools in the streets of towns. This objection must be recognised as correct, for although the closed iron covering is likely to be pierced in some few cases only, it is yet too elastic and pliable to prevent in all cases a bending through and a crushing of the separating fibrous layer between the copper and lead. This necessitates a very careful supervision of all excavations in the neighbourhood of cables, and a further external protection against violent injury at dangerous points by covering the cable with stone or iron plates, or by laying it in brick conduits. It is preferable to fill the latter with sand, to maintain the cable always damp, so that faults which arise can immediately be observed.

As a further objection to the use of insulated cables for the conducting network of central stations for the supply of current it may further be alleged, that through faulty laying of the network, or in its use, faults can easily arise, so that certain parts of it may be heated to such a degree that the insulation of the conductor is destroyed thereby. This is the reason why gutta-percha, and generally substances easily softened, melted, or decomposed by rise of temperature, cannot be used as insulating material for such conducting networks. The lead cable recommends itself above all other underground conductors, since it can bear a very great rise of temperature without any injury. You see amongst the pieces of cable exhibited, one which was taken from the Berlin network

on the occasion of a repair, and which proved, through the fusion of parts of the soil with the jute covering of the cable, that it had been very highly heated. The cable, nevertheless, insulates perfectly well. It may, however, be imagined, that under specially unfavourable circumstances the heating may be carried so far, that the jute separating the copper and lead may become carbonized, and thereby conductive, or that products of distillation may arise, which would make the insulating layer conductive, or even destroy it by mechanical pressure. On these grounds an underground conducting network requires greater care as regards laying, control, and use, than an overhead line, or a net for which bare wires are carried in insulated conduits.

This latter system is, however, only applicable for currents of low tension, and even for these only under certain favourable circumstances. In populous towns, in which the soil under the streets has already been in frequent demand, it will only seldom be possible to arrange accessible and always dry conduits for this purpose ; if these, like the Parisian sewers, have not been carried out in earlier times for other purposes. Unfortunately, the modern great towns are mostly not in the position to lay such a system of accessible conduits under the bed of the street, for frequently, as in Berlin, the nature of the soil and the condition of surface-water are opposed to it, and also water-mains and pipes of all kinds render this exceedingly difficult. Probably the direction which our social development has taken, the ever increasing concentration of men in great business centres, make it an absolute necessity to ease the street traffic by a second upper or lower underground route, in which then the electric conducting network could also find the necessary place. Until then we must be satisfied by finding necessary room in our street-surface, already fully taken up, in order to bury insulated conductors, with as good protection as possible against external injuries.

This is what I had directly to communicate to you. I have preferred to read it, as many statements, even imputations, if you will, are to be found in it, which make an exact rendering necessary. It is hoped, as has been said, that the absolutely unprecedented judgment, which an English engineer of high standing, without having perfectly informed himself, gave before the first and oldest society of electrical engineers in the world,

will become widely known. I have myself introduced him here to the gentlemen of the Allgemeine Electricitäts Gesellschaft; he has, however, not called on me. It would, however, have been easy for him to obtain more precise information, especially when he had formed so unfavourable an opinion. I confess that this is a polemical address, which has something of a business background; but I think, gentlemen, that we can, and must, learn one thing from the English: carefully to defend our rights, and especially against such foreign unconsidered remarks, and I hope that the Institution of Electrical Engineers in London will not refuse this address admission in the columns of its Journal.

I have placed some samples of cable here, which are, perhaps, in so far specially interesting, that they show the special destruction which takes place; I have not brought the large heavy pieces. Such disturbances have taken place, as stated; at these points the neighbouring cables have naturally also been attacked, so that quite a number of injuries have occurred. I have also placed, for those gentlemen interested in them (as we are dealing with a question of cables), cable samples of different sizes, and those for low, high, and medium tension, so that you may have here a general view of the system of conductors carried out by us. I do not wish to assert that equally good permanent lead cables cannot be produced in other ways. I had, however, in the face of this decidedly condemnatory judgment of the English engineer, Forbes, to show the reasons which have enabled us to make better cables, and such as do not possess the faults observed by him in England, that they only last three years, and I beg you to consider my communication from this point of view.

IMPROVEMENTS IN THE ELECTROLYTIC EXTRACTION OF COPPER AND ZINC.*

In the process for the electrolytic extraction of copper or zinc, protected by patent No. 42,243,† the electrolyte consisting of a

* (German Patent, No. 48,959, of 3rd January, 1889, addition to Patent, No. 42,243.)

† P. 504.

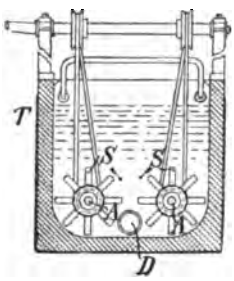
solution of copper sulphate and ferrous sulphate is passed through cells, which are divided by conducting membranes into separate cathode and anode divisions, this being effected in such a way that the liquid first traverses all the cathode divisions one after another, when by means of the current a great part of the copper sulphate is decomposed, and the copper is deposited on the cathode plate, and then passes all the anode divisions in succession, so that by the action of the current the ferrous oxide is oxidized into ferric oxide at the insoluble anode surfaces. The liquid deprived of its copper, and now containing ferric sulphate instead of ferrous sulphate, is afterwards again mixed with powdered roasted or unroasted ore, and then is enabled again to dissolve copper from the sulphur ores, with the formation of copper sulphate, and simultaneously a reformation of ferric into ferrous sulphate.

The subject of the present patent of addition refers to improvements both in the arrangements for dissolving the copper or zinc from the powdered ore as well as in the decomposition cells, whereby the whole of the chemical and electrolytic processes are accelerated and made reliable.

The solution of the metal by means of the oxidized liquid deprived of its copper took place formerly in filter vessels which were filled with powdered ore, and through which the liquid containing the ferrous sulphate was again allowed to pass, or in reservoirs or vats with stirring apparatus, or in rotating drums, in which the liquid with the powdered ore was maintained for a long time in motion. Instead of these separate discontinuously working arrangements we make use of narrow and shallow but long channels of wood or other suitable material which are provided along their whole length with shafts fitted with blades rotating in opposite directions. These shafts with radial arms or blades are turned in opposite directions the one to the other, and thus keep the liquid filling the channels in rotatory motion in a transverse direction to the channel. The powdered ore introduced together with the liquid is thus kept in suspension without being moved in the direction of the length of the channel or trough. Such longitudinal movement only occurs in consequence of the continuous introduction of the liquid at one end and its outflow at the other, thus the duration of the action of the oxidized lye on the powdered ore is regulated at will by the amount of the supply of new liquid.

As for the perfect solution of the metal a heating of the liquid is sometimes necessary, this can be effected by one or more steam pipes of copper or lead, which traverse the whole channel or a portion of it.

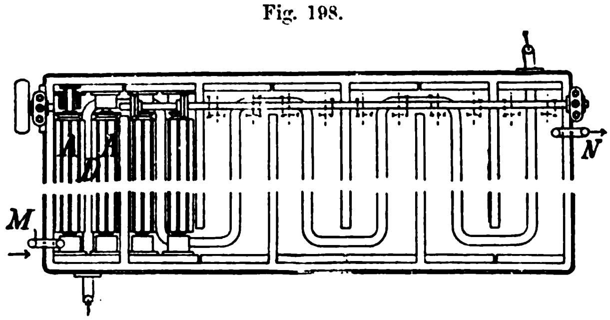
Fig. 197.



In the accompanying drawings the extraction cell is shown in section in Fig. 197, whilst Fig. 198 gives a plan of the whole channel system. In this arrangement, in order to save space, the channel is arranged in zig-zag shape. The walls, T, of the channel are of wood, and in order to make them tight they are covered outside with sheet lead. The shafts, A, provided with the paddles, s, are rotated in opposite directions by means of crossed waterproof cords. The copper heating pipe, D, traverses all the divisions of the channel and makes it possible to raise the temperature to the desired degree.

The electrolytic decomposition cells hitherto used, which are

Fig. 198.

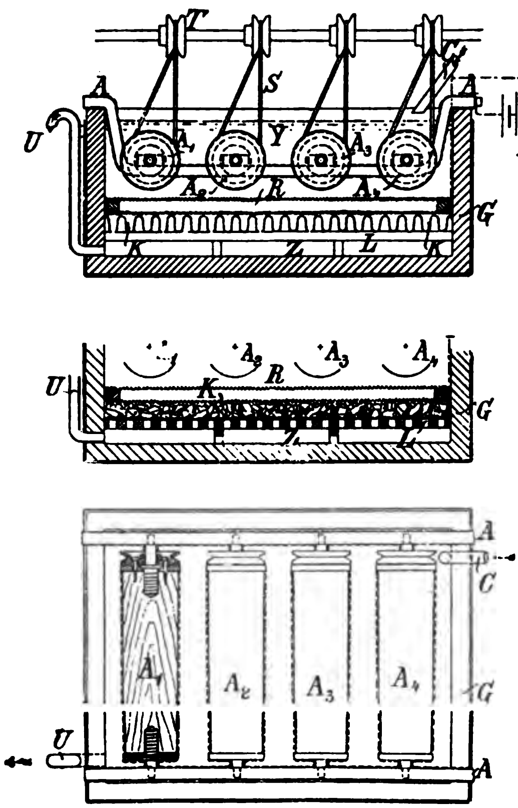


separated by membranes into positive and negative compartments, suffer from the known disadvantages of separating membranes for electrolytic operations. The membranes have either too great a conductive resistance or they are not durable enough, stretch, and permit the passage of the liquid by diffusion or leakage. In Fig. 199 a decomposition cell is represented in section and plan to which these disadvantages do not apply.

A flat vessel *g* of wood with an external covering of sheet lead or

of some other suitable material is provided with a false bottom, L, with perforations on which the anode K, rests. This may consist of properly placed and conductively connected plates of retort carbon, or of lead plates with holes in them, which are

Fig. 199.



covered with retort carbon in small pieces, or finally of deeply corrugated sheet lead, with holes for the outflow of the liquid. Above the horizontal anodes thus formed and provided with insulating connections, a filter-layer, R, is arranged for the purpose of preventing currents in the liquid covering and touching the anodes. This filter can be formed of felt or other organic or

inorganic substance. The surfaces of the cylinders, A_1, A_2, A_3, A_4, serve as kathodes, which are entirely covered by the electrolyte and are continually slowly turned round by waterproof cords. These shafts can be formed with a core of wood, which is covered with wax, cement, or such like, and then covered with a conducting coating to which latter the current is led through the copper gudgeons in a suitable manner.

The regenerated electrolytic liquid, consisting of solutions of copper sulphate and iron sulphate, is led in a continuous stream frequently subdivided to the liquid covering the rollers. The turning of the rollers effects the continuous mixture of the whole of the liquid down to the filter covering the anode. As just so much liquid always flows through the tube U, from the space under the double bottom as flows above at C, a steady flow of the electrolyte takes place through the filter to the anode. At the latter the ferrous oxide of the ferrous sulphate is again oxidized to ferric oxide by the liberated oxygen, in consequence of which the oxidized portions, on account of increased specific weight, fall to the bottom and are then carried away, so that by a proper regulation of the flow of the strength of current and of the amount of copper and iron in solution, the result of the process is that the electrolyte loses in the upper part of the cell about two-thirds of its contents in copper, whilst in the anode division the whole of the ferrous sulphate is changed into ferric sulphate. This latter as it flows off is continuously led again into the channel apparatus with the addition of the necessary powdered ore and traverses the apparatus anew.

PATENT-CLAIMS.

In the process claimed in patent 42,243 :—

1. The solution of the metal from the powdered ore in channel-shaped stirring vats by which the powder is kept suspended, so that it slowly and continuously traverses the whole channel together with the liquid.

2. The arrangement of horizontal decomposition cells with anode plates or rods of retort coke or corrugated lead plates at the bottom, and with rotating cylinders as kathodes in the kathode liquid separated by a filter from the anode liquid.

IMPROVEMENTS IN THE APPARATUS FOR THE MEASUREMENT AND SUMMATION OF THE ENERGY PASSING THROUGH A CONDUCTOR IN CONTINUOUS OR ALTERNATING CURRENTS. PROTECTED UNDER GERMAN PATENT, No. 50,623.*

THE apparatus described in the following, and represented in the accompanying figures, constitutes an improvement on the construction described in the main patent, No. 50,623, and has the object of making the accuracy of the measurement independent of any magnetic masses outside the apparatus, or designedly brought near it. In the construction described in the main patent it is possible by approaching a magnet outside the apparatus to influence the core *a* attracted by the solenoids *b*, as well as the rotatable solenoid S_2, and thus to cause the latter, by moving the pointer *d*, to give an inexact measurement and summation of the electric energy.

In order to remove this inconvenience, the energy meter described in the main patent is altered in such a way that, instead of one rotatable solenoid two or more of them are used, which are fixed to a common axle, and have alternating opposite polarities, so that a magnet approached to the apparatus from without acts attractively on one half of the solenoid, and on the other half on the contrary, repulsively, so that no rotation of the axis carrying this solenoid can take place.

In the accompanying drawings Fig. 200 represents in side view and plan, and partly in section, the solenoids serving to stop the pointer fixed to a common axis, and shows in longitudinal section, as well as in plan, the method of suspension and current-carrying for one of these solenoids.

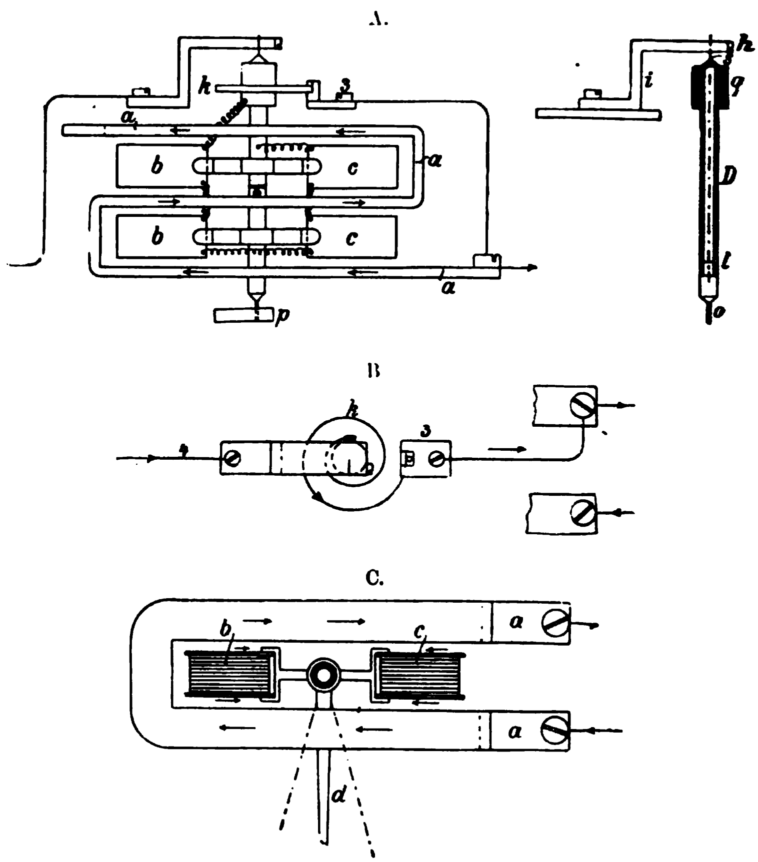
In Fig. 201 is represented a special construction of the driving arrangements for the counter, which differs so far materially from the arrangement described in the main patent, that in this case the lever *g* there mentioned acts upon the counter, not during its forward motion, but only during its backward motion, therefore,

* (German Patent, No. 57,785, of 16th August, 1890; addition to Patent No. 50,623.)

after its contact with the pointer *d*. Fig. 203 serves to show a special way of suspending the rotatable solenoid, and Fig. 202 shows a dial for the readings in ampère hours.

a is a fixed strip of copper, or other metal, rigidly connected

Fig. 200.



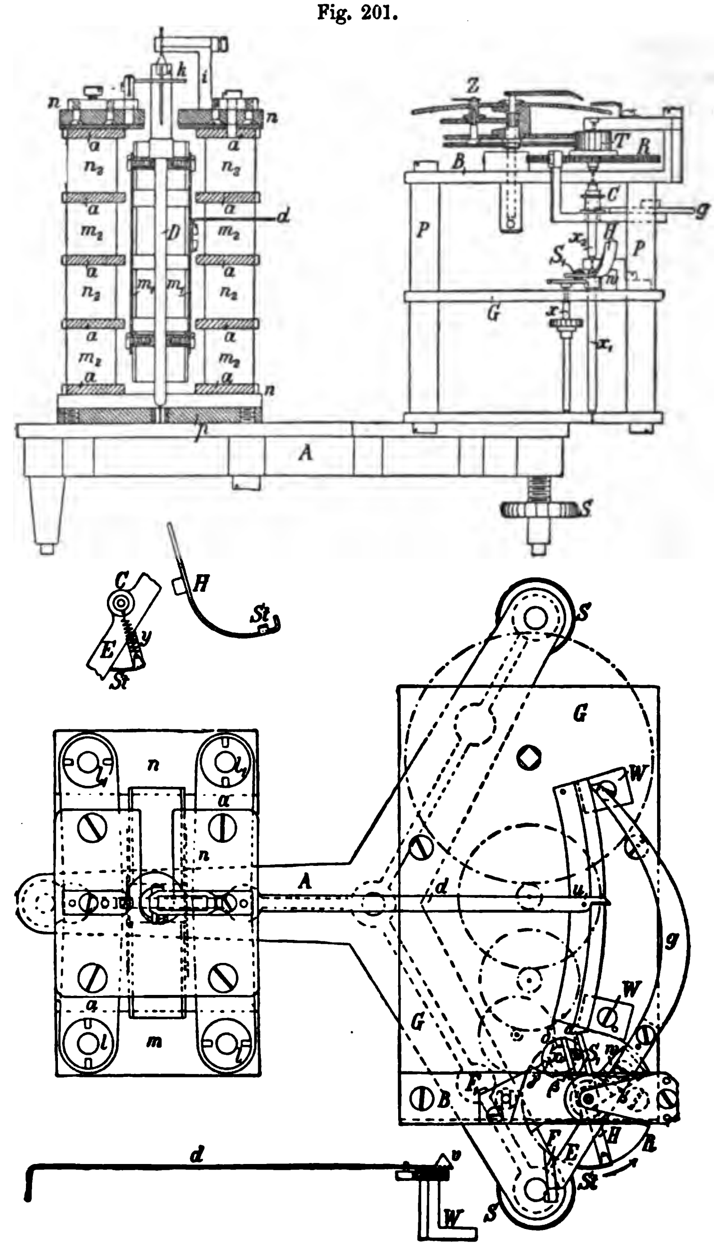
with the case of the measuring apparatus, which, as shown in Fig. 200, is so bent into several windings lying above one another, and alternately running in opposite directions, that it acts as a solenoid, and surrounds the rotatable solenoids *bb cc*, and leaves a

sufficiently large intervening space between its individual windings, so that the rotatable solenoids can move freely between the windings of this metal strip *a*. Each pair of solenoids *b c*, situated on opposite sides of the axis D, possess opposite polarity, and the solenoids situated on one and the same side of this axis equally possess alternate opposite polarity, so that the turning moments exerted by all the solenoids on sending a current through are summated. In order to render an absolutely frictionless turning of the solenoids *bb cc* possible, the mode of suspension represented in Fig. 200 is chosen, which consists in these solenoids being fixed to a hollow axis D hanging to a thread *s*, so that there is no friction in bearings; but all that has to be overcome by the rotation of the solenoid is the torsion of this thread *s*. The thread *s* is preferably made of platinum, and is fixed on the one side at *h* to the bearer *i*, on the other side at *l* to the lower portion of the hollow axis D; *o* is a pin, which projects in a hole of the block *p* rigidly connected with the measuring apparatus, and serves for the purpose of maintaining the axis D always in the same position. In order to render possible the passage of the current to the rotatable solenoids a spring *k* is provided, which is in conductive connection on the one hand with the lead 3, and on the other with a sleeve *q* fixed to the axis D, but insulated from it, and communicates the current passed through the conductor 3 to the solenoids *bb cc* connected in series. From the upper solenoid *c* the current flows back again to the axis D, and from here through the wire *s* to the bearing *i* and the conductor 4.

In Fig. 201 is shown a frame GG firmly screwed to the tripod A, provided with levelling screws SS, which serves to carry the mechanism intended for the regular motion of the eccentric axis *x*, which latter is here only indicated, and the motion of which is regulated in the usual way by a balance.

On the upper frame-plate is a circular-shaped angle-piece indicated by WW, which is provided with ampère divisions. This angle is intended to prevent the bending of the pointer *d* when it touches the swinging lever *g* on the oblique plane *v*, and thereby incorrect counting, as a slight touch between this lever and the pointer is sufficient to depress the latter by the pressure of the lever *g* on the inclined plane v_1, when a point fixed to this pointer at *u* is stopped by the rough surface of the angle-piece W. The

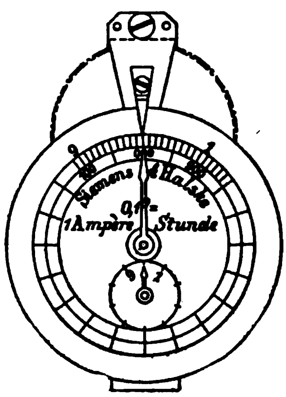
Fig. 201.



counter Z indicating the current consumed is constructed similarly to those used for water-meters, and its construction may be taken as understood. This is also supported by the bridge B fixed by the pillars PP to the upper frame-plate.

The axis x_1 is pivoted below in the frame-plate, and above in the angle-piece w resting on the upper plate, and carries above the upper frame-plate the two-armed lever H, of which the arm bent upwards serves for attaching the spiral spring y, and is provided at the side with a support st. The other straight fork-shaped arm

Fig. 202.



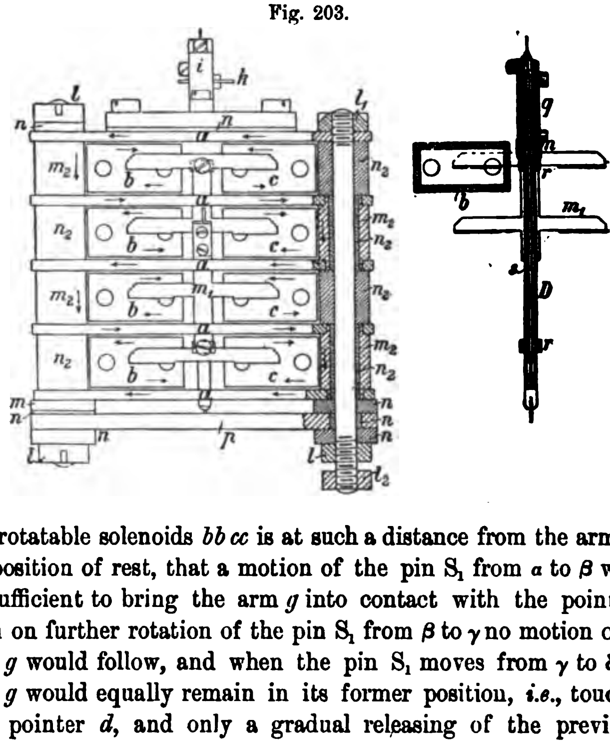
of the lever H is regularly moved forward and backward by the eccentric axis x. Above the axis x_1 the axis x_2 is pivoted in the angle-piece W and the bridge-piece B. Above this is the wheel R, provided with fine teeth, resting on a short axis, and connected with the pinion T gearing in the counter.

On the axis x_2 is a two-armed lever E, which is provided in the centre with a bush C for fixing the spiral spring y. The straight end of this lever carries the arm g, whilst the other end bent at a right angle at its upper part carries the blade-spring F gearing in the wheel R.

So long as the arm g finds no resistance, the lever E, in consequence of the tension exerted by the spring y, follows the motion of the lever H, brought about by the eccentric axis x. In the position shown, the lever H would move, for example, in the

direction of the arrow, and as the tension of the spring y is stronger than the friction of the spring F, this latter would slide on the wheel R stopped by the spring F, until the lever g was resisted by the pointer d. If one assumes, for instance, that the axis x turns in the opposite direction to the hands of a clock, the eccentric pin S_1 actuating the lever H would pass from the position represented in Fig. 201 by α through the points β γ δ, and then return to its original position. If one further supposes that the front end (the sloping surface v) of the pointer d actuated by

Fig. 203.



the rotatable solenoids $bb\,cc$ is at such a distance from the arm g in its position of rest, that a motion of the pin S_1 from α to β would be sufficient to bring the arm g into contact with the pointer d, then on further rotation of the pin S_1 from β to γ no motion of the arm g would follow, and when the pin S_1 moves from γ to δ, the arm g would equally remain in its former position, *i.e.*, touching the pointer d, and only a gradual releasing of the previously stretched spring y would take place. Finally, by a further turning of the pin from δ to α the stop St strikes against the lever E and moves the arm g backwards, when simultaneously the toothed wheel R of the counter is set in motion by the spring F. The paths α to β and δ to α are naturally equal, and it follows that

the wheel R is turned through the same angle by the backward motion of the arm *g*, as if the arm *g* during its forward motion acted on the counter. This motion of the wheel is so transmitted by the pinion T to the counter, that the consumption of current for the duration of one revolution of the axis *x* corresponding to the position of the pointer *d* is shown on the dial.

In Fig. 203 metallic pieces are indicated by *m*, and on the other hand insulating construction pieces by *n*. *p* is the base-plate resting on the tripod A, on which the low resistance solenoid, consisting of copper strips *a*, and the collars m_2 and n_2 are fastened, insulated by bolts and nuts. At l_1 is the beginning and ending of the solenoid windings; the outer connections are effected by means of the nuts l_2. The wire bobbins, made of insulating material, for the fine windings are held together by the metal crosses m_1 by means of the screws and intermediate pieces *r*; these bobbins are firmly connected with the hollow axis D. Over the upper binding-piece *r* the collar *q*, insulated from the axis D, is firmly clamped to it, and serves for the further joining up of the connection coming from the case *b* by means of the spring *k*. The other end of the windings of the swinging solenoid is led from the casing *c* to the metal cross-piece m_1, and thus through the axis D and the suspension wire *s* to the angle piece *i*.

The manner of action of the above described construction of moving solenoids is the following:—

If the rotatable solenoids *bb cc* connected in series are of alternately opposite polarity, and at the same time the windings surrounding the solenoids are traversed by a current, the solenoids *bb cc* suffer a deflection in such a way that the solenoids *bb* on the one side of the axis D are rotated by the windings of the strip *a* in one direction, whilst the solenoids *cc* are rotated on the contrary in the other direction, so that hence the pointer *d* firmly connected with the axis D experiences an angular deflection, which bears a determined proportion to the electric energy to be measured. By this angular motion of the pointer *d*, as is already described in the main patent, the motion of the lever *g* is limited correspondingly to the quantity of current traversing the conductors 1, 2 at the moment, and by the transmission of this motion to a counter the energy is indicated which has passed through the conductor a determined interval of time.

Patent Claim.

In the apparatus protected by patent 50,623 for the measurement and summation of electric energy, by which the angles of rotation of a suitably formed lever are summed up, which is rotated at determined intervals of time, until it makes contact with a pointer determined in its position by the electric energy existing at each moment; the construction of a fixed solenoid *a* consisting of many windings lying above one another and running alternately in opposite directions, which surrounds two or more solenoids *bb cc* of alternately opposite polarity suspended so as to move between these windings, and by the deflection of which the pointer *d* actuating the counter is placed in positions corresponding to the electric energy consumed at every moment, without the deflection of this rotatable solenoid being influenced by any magnet or magnetic masses brought outside the apparatus.

APPENDIX.

POSITIVE PROPOSALS FOR A PATENT LAW.

Memorial of the Council of Elders of the Berlin Merchants to the Royal Prussian Minister for Commerce, Trade, and Public Works.*

Your Excellency has invited us by your decree of the 5th August, 1863, to a detailed expert expression of opinion on the question "Whether, having regard to the present condition of industry there is now any need of the stimulation of the genius for invention aimed at by the grant of patents since the Prussian system of patent legislation as well as those of other lands were accompanied by important disadvantages." As representatives of a corporation, which comprises in itself equally important commercial and industrial interests, we have endeavoured to examine the proposed question in a thorough and unprejudiced manner, and we have the honour in what follows to submit the result of our careful consideration.

Many points of view may be taken in answering the question; that standpoint from which the granting of patents is generally defended, which has on the other hand been assailed especially in recent times, is that of the moral title of the inventor to the protection of his intellectual property. It can certainly not be contested that this way of looking at it has a certain right about it. If in the State generally products of intellectual activity, as for instance works of art, writings, etc., are protected in favour of the author in preference to unauthorized reproduction, and thereby a certain kind of restriction is imposed on the whole community, the demand is not unreasonable, that this protection should be extended as far as possible to all provinces of intellectual production; that therefore, especially inventions in the province of science, which equally with literary or artistic work are valuable in a certain measure as an accumulation of work bestowed, are not only to be considered, but also to be treated as actual property of the inventor. Indeed, technical inventions have without doubt a much greater right to protection, because

* (Annals of the North German Confederation and of the German Customs Union, 1869, p. 41.) 1863.

as a rule they depend on costly experiments, or at least require them for their practical carrying out, and in this sense are to be equally considered as an accumulation of capital and labour.

Nevertheless we do not consider we are called upon to take upon ourselves the decision of the question in this sense. It might even be considered doubtful whether the arguments resting on the basis of moral right are quite decisive. The interest of the community forms the highest law to which individual interests must give way. If it could be shewn that the general good was helped by the abolition of patents for invention, then inventors would have to devote their powers to other work offering better reward, if they are not willing to be satisfied with the advantages which may possibly accrue to them without patent protection. We therefore consider it more suitable to limit ourselves entirely to examining and answering the question whether it is advantageous or not for the progress and further extension of industry, as well as of commerce inseparably connected with it through its interests, if an exclusive right of possession is given to inventors for their inventions.

It cannot be denied that patents for invention constitute a restriction of industry and commerce, and in certain cases a burden for the whole consuming and producing public; this burden is so much the greater the further the patent protection extends, and the more easily it is to be obtained the longer the great mass of unimportant and useless patents continues in legal force, finally and especially the more difficult it is made to the public by the granting of a patent to discover what is legally patented and what is not. On the other hand, however, the phenomenon that the rapid extension of industry in all ages and lands coincides with the extension of patent legislation, is of sufficient weight not to abolish the principle of patent protection with some customary but by no means decisive phrases, for the reason that patents are no doubt a burden for the public.

If patent protection is considered only from the standpoint of the Prussian, and generally of the Zollverein legislation, it is then certainly difficult to recognize a causal connection between both developments. The Prussian and Zollverein patent legislation, although much younger than that of the other great industrial States, has yet restored to the patent for invention its original character, that of a privilege which is accorded as a grace to the inventor, as a reward for his service rendered by the invention. The invention is kept secret in the interest of the inventor to be recompensed, and only its title is published as a warning to those likely to infringe it. All those carrying on trades are as regards these patents in a truly hopeless condition, if they wish to improve their business. If their improvement corresponds with the title of a patent that has been granted, this continually hangs over their head like the sword of Damocles, because it gives them no means of learning the contents of the patent specification. It necessitates a detailed memorial to the

Imperial minister of commerce in order to learn after the lapse of a long time whether the improvement introduced constitutes an infringement of an existing patent or not. In any case they run the risk of falling into vexatious conflict with the patentee, and having to expend much trouble as well as money. It may be considered fortunate for home industry that such secretly kept patents are only granted in comparatively small numbers, as the technical officials, on whose subjective pleasure the grant of a patent depends without any control, are only disposed to do so in comparatively few cases. The keeping secret of Prussian patents is, however, also connected with other disadvantages which restrict the progress of industry. As a royal official only gives patents for such inventions as he considers worthy of this favour, it is natural that the public should have the impression that all patented inventions are of great use and value, an impression which is generally followed later by the bitterest disappointment. If, moreover, the inventor has fulfilled the easily realisable conditions of proving how to carry out the invention, still the patent remains unhindered in force, notwithstanding that it never comes into use and brings not the slightest advantage to the inventor to be rewarded through it up to its expiration, together with the complete stoppage and disturbance of the manufacturing public. Thus even in the most fortunate cases the benefit which the inventor can derive from a Prussian patent is almost always entirely imaginary. For one thing the duration of the patent, generally five years, which depends altogether on the uncontrolled will of the technical commission, is almost always too short, at least as regards important inventions, to bring them into extensive application and to make them generally adopted. The inventor, moreover, does not possess a secure legal protection, as the judgment whether an infringement of his rights has taken place or not, again devolves on the quite arbitrary decision of the same technical commission. Finally, in the great majority of cases, the circumstance that the introduction of patented articles from other Zollverein States cannot be prevented, renders a Prussian patent almost worthless to the possessor. Therefore with respect to patents in Prussia and the Zollverein States one can only agree in the general judgment that they constitute a great obstacle to the home trade without bringing it the least benefit, and they are of equally little advantage to the inventors, they therefore do not prevent them from depriving the fatherland of their ideas, their labour and their capital, and from carrying them to the paying English or French market.

If it were only a question whether the Prussian patent law in its present condition should be maintained or not, we should not hesitate a moment to declare for its complete repeal.

But the question assumes quite a different appearance if one takes a view of the patent legislation of all other important industrial States.

As is known, the English parliament determined, when at the commencement of the seventeenth century it abolished the mischief of

personal monopoly which had risen to an unbearable height under James I., that in future monopolies should only be granted for inventions, and then only on the condition that the latter should be disclosed. This condition of the publication of the things patented has been introduced into the patent legislation of all other great States with the solitary exceptions of Prussia and Russia, and has evidently contributed in a very marked degree to the rapid progress of industry which commenced at that time. In fact one only needs to look over the list of contents of English patents to convince oneself that an abundance of fruitful ideas of immeasurable value to mankind has been supplied through this channel. Even at the present day the specifications of English, American, French and Austrian patents form almost the sole source from which the technical journals of all countries obtain their material, even at the present day the diffusion of new ideas by means of publication of patents is the one driving wheel which maintains the industry of all countries in its rapid progress. That solitary countries like Switzerland without patent laws, that Prussia with its patent legislation equally hostile to industrial advance, notwithstanding the want or at least insufficiency of patent protection, enjoy a similar industrial development as those older industrial States, is explained by the fact that the patent publications have been at their command as in general at that of the whole world, and cannot be cited as proof against the immeasurable benefit which patents have afforded, and in equal measure afford at the present time.

The question, however, has been raised whether patents, which have evidently greatly assisted in the development of industry, as in earlier times guild and special privileges did, are necessary now that industry has attained its present height, and have not become superfluous through competition and easy communication. It has been specially noted that in England itself, the cradle of patent legislation, a movement has begun, which has their repeal as its object.

If one allows—and one must, if one is not to deny circumstances founded on fact—that the uninterrupted industrial progress at the present time is the indispensable condition of the growth of industry and commerce, if it is conceded further that quick diffusion of all ideas and discoveries, even the so-called impracticable and inapplicable, and therefore not directly useful, is the most powerful motive spring which drives the world forward, the question is then thus restricted: are there more simple and less troublesome means of prompting the authors of inventions to publish them immediately and fully, and so to make the new thoughts lying in them advantageous for the general good? This question must be absolutely answered in the negative.

Every inventor naturally wishes and desires to make his invention—as a rule the result of long work and often costly experiments—as profitable as possible for himself. If the State recognizes no right of

property for him, the publication of his invention puts an end to his property. He therefore finds himself constrained to keep his invention as secret as possible in order to profit by it himself. If he is himself a manufacturer, or if he has the desire and means to become one, he will seek, if the nature of his invention permits it at all, to benefit by it as far as possible, quietly and under the protecting cover of secrecy of manufacture; otherwise he will seek under the promise of secrecy to interest another in his invention, and if he succeeds he will begin secretly in combination with this other to turn it to the best advantage. Experience teaches that such factory secrets are preserved for whole generations in countries without secure patent protection or in manufactures which are not suitable for patenting. In this way, however, not only is the invention in question lost for a long time to the world, but also all those to which it might have given rise in other minds. Certainly, also, many inventions would finally become known through the originator himself, if his ambition is greater than his egoism, or through falseness and treachery; yet this will always be the case only to a limited extent, after a long interval of time and in an incomplete manner. A quick, complete, and faithful publication, such as is obtained by patent specifications, could be attained in no other way. The secret trading, so fortunately obviated in consequence of patent legislation, would, therefore, spring up again, and the living vigorous extension of industry of our century would be completely checked. No other means can be thought of to avoid this than to compel the originator of an invention to make it public in his own interest, and this is the true rational basis of a proper patent law. The patent is, in this way of looking at it, an actual contract between the State and the inventor; the former, as representative of the interests of the public, allows to the inventor for a term of years, which must only be so great that it suffices to attain the purpose, the sole right of disposal of the invention; the latter, on the other hand, undertakes at once and fully to make the new idea in the invention available for the public good. It is the business of legislation to take care that the community should derive the greatest advantage from this contract.

Yet, irrespective of the publication, essential advantages accrue to society from granting the inventor the right of property for a limited number of years. Only in the very fewest cases is an invention useful in its original condition, usually, and especially with inventions of most importance and departing most from what is known and proved, a long series of experiments and a great expenditure of time, labour, and capital is necessary to overcome all the difficulties in the way of what is new, and to give the invention a practically useful shape. Only a prospect of considerable profit can stir one up to the expenditure of this great sacrifice. By patent protection for a series of years, combined with the fatherly love which every inventor has for his idea, he becomes a natural guardian and counsel for his invention; if he

has not himself the necessary means, the title to his invention obtains it for him, he receives capital to make necessary experiments for carrying it out against the security of a share of the future profit. In this way Watt succeeded in obtaining the rich Boulton as a partner in consequence of his 14 years' patent; it is true that it required all Boulton's wealth and 15 years' work to overcome the greatest difficulties in the way, and only the extension of the patent for another 14 years by an Act of Parliament brought them the deserved profit. But if both had failed over it yet the world would have had the steam engine, and with it have gained access to a new period of industrial progress of quite unexpected splendour. Many such cases may be adduced where lengthy, tenacious clinging to an idea and working at it, nourished by the prospect of future important profit, which at first appeared vague and valueless, was finally crowned by an important invention putting new life into every branch of industry. The real advantage and benefit of the invention for the world does not consist in the ideas which often die away unnoticed, but in their painstaking and complete working out. How often are really good proposals made and remain unnoticed just because they are proposals; years after, again sought out by a painstaking inventor or discovered anew, the same thoughts lead to the most brilliant results. To whom does not occur as an example the invention of aniline colours made already years ago in our fatherland but only made valuable quite recently?

It may be granted that the total work of all will in the course of time reach the same goal, if after abolishing patents, the inventor no longer finds through his material interest the necessary impulse and the necessary means for this heavy, and in a great majority of cases, thankless work; nevertheless, the time necessary for the work, the labour expended, and the capital required, will be incomparably greater.

It may be objected that during the time when the invention is the individual property of the inventor, the public are deprived of its advantages; but even here the interest of the inventor properly understood is that of the public. The enormous development of manufacture in almost all branches of science makes it ever so much more advantageous to the possessor of a useful patent to make the invention available to all against payment of a small share or profit or of a fixed sum. Therefore, in the countries where a secure patent protection exists, the inventor will very seldom work his invention alone, he will, on the contrary, be always strongly induced to bring the same into general use. The time of duration of a patent is therefore in no way lost as regards the total industry, the branch of industry concerned will, on the contrary, be quickly entrusted with the new discovery under the protection of the patent law, whilst in countries where no patent law exists each one must himself make the experiments necessary with new inventions, and therefore besides the necessary loss of time, must usually pay much more for his experience than the

amount of the honorarium to which the inventor lays claim. Experience also teaches us everywhere that new inventions are most quickly domiciled where the inventor protected by a patent works for its introduction, and makes the store of his collected experience accessible to all. All who now use the new invention are fellow workers in perfecting it, and in this way the branch of industry affected receives an advantage over that of other countries which cannot at all or only with difficulty be overcome, and in the latter flourishing branches of industry and commercial interests closely connected with them have often been ruined.

If, notwithstanding that a patent law, which on the condition of publication awards his invention to the inventor as an exclusive property for a series of years, manifestly held out special advantages to the industry of the country, just in that country in which this arrangement has longest existed, viz., in England, a movement has arisen, the aim of which is the removal of this arrangement, one may be assured in advance that defects of legislation must exist which have unnecessarily increased the burden to the public by the patents, and that that movement will have as an actual consequence not the repeal but the improvement of the law. England, which owes its great industrial supremacy in a great measure to the circumstance, that it first and long before all other nations possessed a patent law, can and will never get rid of its patents for invention, but on the contrary desires to reform its patent law. It has already for some years past made a commencement, as it has adopted the principle of the inventor paying fees to the State, increasing with the duration of the patent. According to the former English patent law patents were granted without proof of any kind for a term of fourteen years against an immediate considerable payment. It may be assumed that only 5 per cent. of the patents taken out in England have been practically tested in their original form and have become profitable to the inventor. The patents were taken out once for all and paid for, and remained during the whole 14 years a burden on the public. With the great number of patents taken out in England by inventors in all parts of the world, this dead load must have become intolerable in time. To this must be added that the English law allows inventors to give their claims an unreasonably broad basis, since they may in the future attach every possible improvement or application of their invention or of a portion of it. In this way, in course of time, a chaos of claims has arisen amongst which only those skilled in the law can find their way. By the introduction of the rising scale of fees it has nevertheless come about that in recent years only a small portion of the patents taken out have outlived the third year and only 5 to 10 per cent. the sixth. A further improvement of the law for the relief of the public is nevertheless undoubtedly necessary, and to all appearance the present movement directed against patent legislation will have this result.

In France they are similarly circumstanced, where also a reaction has set in against flooding the public with useless but on that account more burdensome patents. The uneconomical principle of intellectual property has there induced the legislature to render the obtaining of patents too easy and not to employ sufficiently practical means to remove the dead load of useless patents. Supply and demand must in this case also regulate the price which the community pays to the inventors for the disclosure of their ideas and their experience, and for the sacrifice which the carrying out and diffusion of their inventions occasions, the price is too high and must be reduced if the congestion becomes too onerous. A reason for the complete removal of that business from which fresh energy of life streams to all the rest, can, however, never be found in it.

Lastly, the question still remains to be discussed, whether Prussia could not leave to the older large industrial States, and perhaps also in future to its former associates in the irrational secret system of patents called into life by it in the Zollverein, to take care of the publication of inventions through continuous patent protection, and as formerly Switzerland, Mecklenburg, and the Hanse towns could enjoy with others the advantages existing in other States without any proper patent legislation. Setting aside the odium, indeed one may say the immorality of the exclusion of a great commercial and industrial State, like Prussia, standing at the head of the Zollverein, from the burdens which the rest of the civilized world imposes on itself by patent legislation in order to make all new thoughts and technical experience as quickly and as completely as possible available for their general good; setting this aside, such an isolated step on the part of Prussia, as already shown, would be combined with great direct material disadvantages. A smaller State with an industry confined to a few self-contained branches of manufacture might accomplish such a system, perhaps for a long time without direct recognizable disadvantage; a great industrial State must however strive after leading, and virtually achieve it, at least, in some branches, if it will not lag behind more and more. For only the consciousness of supremacy, or at least equality, draws capital and intelligence into its service, opens to its industry the sources of the market of the world, and gives it the necessary security for the struggle with competition on all sides.

We believe we have shewn in what precedes that patents for invention, with obligatory publication of their contents, form an indispensable condition of the prosperity and advance of industry, trade and commerce, that more important States carrying on industries, or confederations of States cannot dispense with patent legislation without material disadvantage, and that the agitation arisen in recent times for its total abolition depends partly on incorrect views of the true meaning of patents for invention and their benefits, and is partly and indeed predominantly a consequence of the drawbacks of existing patent legislation, and will have their improvement as a probable consequence.

In our opinion a suitable patent law must effect in the first place the quick, certain and complete publication of the thing patented; it must further compel the inventor, in his own interest, to devote time and means to the perfection, practical accomplishment, and general introduction of his invention; at the same time it must also prevent the accumulation of an oppressive burden of untenable and worthless patents dangerous to the community. This legislative action is already partly aimed at in the introduction of the system of progressive taxes previously mentioned, for if an invention is actually of no practical value, the inventor will soon be convinced of the uselessness of his patent, and will then be chary of paying further and increasing taxes for it. Moreover, there is in one direction, the basis of which is found in the American patent law, a second available means of diminishing the burdensome number of useless patents. It consists in each patent applied for being submitted to the judgment of an official before its formal issue and publication, who has to examine its formal and actual validity. If this examination shows on any grounds that the patent is untenable and would constitute a useless burden to the public and the inventor, the official has to advise the inventor to withdraw his application, with a short statement of the reasons. If the inventor does not follow this advice within a certain space of time, the patent is issued and published with the warning decision of the official. The opinion of the examiner has by this procedure, therefore, no decisive influence on the grant of the patent; the principle of the process of application remains on the contrary of full value, yet the most important disadvantage of the process of application is removed by its combination with the proposed procedure of previous examination. The inventor is usually led to the conclusion by his own examination of the decision of the official, that he was in error and to withdraw his patent application. Otherwise, the public is warned by the advisatory decision of the formal or material defect in the patent; it therefore loses its checking action in the carrying on of business. As the inventor, however, by an action which he brings against an infringer, can bring the question at all times to a legal decision whether his patent is actually and formally valid or not, the preliminary examination by the official loses the appearance of arbitrariness which would attach to it if the question were finally decided by him. The judgment, based on the opinion of sworn experts, will assure to owners of patents, as well as to the public, the feeling of secure legal protection; and if, as is to be expected, the judgment in the great majority of cases confirms that of the examiners, the respect for them can only increase. In order to attain this, they must restrict themselves only to passing a dissuading decision when the untenableness of the patent applied for is clear, and in doubtful cases leave the parties to bring their claims for judgment before a judge, whose right to bring a sufficient number of experts before his tribunal places in his hands more, and more certain, means of arriving at a well-founded and correct judgment than a government official possesses.

We think we may assume that patent legislation founded on this basis will in general correspond all the more perfectly with the true interest and needs of industry and commerce as well as that of the public, the greater is the territory in which it has sway, and collect our opinions in the following points unanimously agreed to by our Council:—

1. We absolutely condemn the system prevailing in Prussia of patents kept secret and granted on the ground of a departmental preliminary examination, and we recommend the earliest possible repeal of this law.

2. On the other hand, we consider the grant of patents for invention with the absolute obligation to publish as indispensable, and cannot, therefore, recommend in principle the abolition of patents for invention.

3. We consider as the most suitable patent law one embodying application, consultative previous examination, judicial protection of the inventor as well as of the public.

4. We support a system of patent fees on an increasing scale.

5. We can only recognize an international uniform patent law, or one including at least the whole customs territory, as a fully satisfactory solution of this weighty question, especially important for the further successful progress of industry and commerce.

MEMOIR REGARDING THE NECESSITY OF A PATENT LAW FOR THE GERMAN EMPIRE.*

THE great height to which German industry has risen in the last ten years depends really on two factors: imitation of foreign inventions and low wages. With the exception of certain branches founded upon natural sciences highly developed in Germany, the latter was not sufficiently intelligent, too young and too poor to be able to vie in original and important works with the industries of the older industrial states. It was, therefore, its natural endeavour not to produce what was new; but to imitate, and with the help of its low wages to produce the imitated goods cheaply. The published patent specifications of other countries supplied it with rich materials for this imitation, and where this did not suffice, the spying out of the arrangements and methods of manufacture was systematically carried on with the assistance of the governments. In this way German industry was enabled to compete successfully with foreign industry not only in Germany but

* 1876.

even in the markets of the world, and by increased export of manufactures to re-establish temporarily the balance of trade which had been disturbed by the increasing diminution in the exportation of German raw materials. The very imperfect and unworkable patent legislation of the individual German States assisted it in this, as imitation free of expense was thereby facilitated.

The necessary consequence of this development of German industry was that German manufactures, both at home and abroad, acquired the reputation of cheap but bad goods, and that manufacturers who by way of exception manufactured good articles, often found themselves compelled, in order to obtain a corresponding price, to bring their manufactures into the market under foreign names. By the English prohibition to import manufactured articles with the stamp of English firms, and by commercial treaties, this practice, ruinous for the reputation of German industry, was very successfully suppressed; the undervaluing of German manufactures still existed, and caused each crisis which happened to have a much deeper influence on Germany, because with a much diminished demand, only the best known firms and best manufactures found a market.

This German industrial system received a first heavy blow by the perfection of working machines introduced from America, and the wholesale manufacture by machinery based upon it. As this manufacture is not only much cheaper than the productions of hand work, even with very low wages, but produces much more perfect results than the latter, competition with it is impossible. So America, amongst others, has deluged the world with its sewing machines, and now even competes successfully, and even in Germany with the Black Forest, in cheap clocks of incomparably better quality. Such special goods, based on wholesale manufacture, depend almost without exception on new inventions patented in the respective country and cannot be imitated, as the cost of the arrangement and of the carrying on, as well as the risk, are too considerable, and the start gained in the possession of the market can only be overcome with great difficulty.

German export industry received the second really deadly blow through the short giddy rush of commercial activity and speculation, brought about by the great political events of recent times, the sound of the milliards, the unsoundly developed credit system, and the home consumption of the country raised to an unwarrantable amount. With the considerable fall in the value of money thereby caused in Germany was necessarily connected a considerable rise in the price of labour, and with it disappeared the special foundation of our export industry. On the other hand no help can be given either by protective tariff, which is of no assistance to create export trade, or by the screwing back of wages to their former point, which would be only accomplished after the impoverishment of the land had taken place. Only when we shall have succeeded in making the home industry of equal standing in performance and reputation with the foreign can we reckon

on a renewal of our export activity. This can only be obtained by increasing and strengthening the intellectual creative and inventive powers, which are active in industry, as well as by raising the solidity and probity of industrial activity and commerce.

These necessary endeavours are not only not promoted by our state regulations and principles of government, these latter have on the contrary been one of the most important causes of the unfavourable direction which the development of our industry has taken. To refer to this in detail would lead too far. Notice shall therefore only be taken of the significant circumstance, that in the older industrial States, and especially in England, the civil engineer, rising in his profession in consequence of his prominent technical performances, has a high social position, exerts a powerful influence on the state management of all technical concerns, and is summoned to the highest positions of the state, whilst with us industry is only considered as business and is without esteem and influence. With us there is no place in the state organisation for the civil engineer, or any actual engineer; with us the architect is the technical organ of the state administration, the only material considered as qualified out of which the state forms its technical dignitaries, advisers and officials. With us a man must have studied architecture, not only, as in other countries, to build palaces and mansions, but streets, bridges and canals, as well as railways and telegraphs. Not even the laying out of our factories is permitted us without the directive action and control of the architect, to whose arrangements and decisions we must everywhere submit. That this multiplicity of study must lead to superficial knowledge and semi-knowledge, and can neither produce capable architects nor engineers, is quite comprehensible.

Unfortunately, the social and state undervaluation of industry is at present not without authority. The few engineers who have risen by skill and pre-eminent personal performances which it has so far produced, draw back discouraged and indifferent from public business, whilst mediocrity presses forward as everywhere. But how can capable and talented men continue their work in the German industry and thrive if their performances remain unacknowledged and their intellectual labour unprotected? How shall special factories for manufacturing in quantity arise, which probably, next to home industry, will in future form the basis of our whole industry, and especially of our exports, if the want of protection to inventors in the mother country prevents capitalists from supplying the means for carrying out inventions and the production of special factories for turning them to advantage, and forces the inventor himself abroad? Many talented German engineers are not found in Germany, but more in England, America, and other industrial countries, where they contribute largely to make competition with the foreigner impossible for their mother country.

Theoretical political economy, however, maintains that patents do not promote inventions and bring the inventors no benefit; the

formation and introduction of inventions would be effected more quickly and better through the untrammelled work of all than by the inventor himself. In the practical sphere these are fallacies which refute themselves. For invention in the first place inventive heads are required which only unfold themselves and remain where they find favourable ground and protection for their work. It is hence quite immaterial whether patents actually bring them benefit or not. They believe it and therefore go where patents are granted them, where they have the best prospects of rising and may be themselves the most competent judges of their own interest. That the work of all most quickly and best develops and introduces inventions is an error founded on fact, as may be at once recognized since technical progress has always been most vigorous in those countries in which inventions are best protected. Political economy theorists who are not practically engaged in industry, generally start from the false view that an invention is nothing but an idea without trouble, and bring it into a certain opposition to work. They thus confound ideas with inventions. The idea is in itself without real value; it becomes so only after passing through a tedious, costly, and often for the inventor, dangerous path, through which it must be elaborated to become an invention worthy of a patent. It is almost the same path that the conception of a work of art has to pass through until its completion. For inventions, however, the greatest difficulties begin after this passage, they must undergo the fire test of practice in which by far the greater number succumb. Then they have yet to sustain the most difficult fight against habit, prejudice, and the inert force of what exists, which they must destroy in order to procure a position. The "work of all" cannot perform all this, it would only effect, that this "all" would have simultaneously to traverse the same laborious and expensive way, would therefore certainly be very uneconomical. As a rule the fatherly love of the inventor is able, combined with the expectation of great honour and gain in the future, to create the necessary quantity of self-sacrificing work and means, for the accomplishment and introduction of an important invention. Thus may be explained the feeling of irritation about injustice undergone which takes possession of every inventor, when his invention, the child of grief and of heavy pains and cares remains unprotected, and so is destroyed or becomes a booty to everybody without trouble. This irritation about protection refused to his putative property more than the prospect of material profit, brings it about, that the inventor prefers to seek protection for his invention abroad than to abandon it to the "work of all" in the fatherland. There it is willingly granted to him according to the patent legislation of most countries with as full equal rights as to the native. If the inventor then finds the ways and means to perfect his invention and to introduce it he is as a rule lost to the land of his birth, and in case he is successful draws many others after

him by his example, and as a rule those most energetic and most capable. The remarkable phenomenon is thus explained, that there is in Germany so great a number of young well trained engineers possessing much knowledge that it forms a plantation for the whole world, but that as regards prominent engineers other states are rich and we are very poor. There is, however, at the same time the comforting consolation that a change for the better can easily be effected, and that German industry even bears in itself the main condition of a prosperity without equal. This is the high development of the study of natural sciences in Germany, the basis of all technical progress and the better scientific and technical training of our youth which has brought it about; that with us natural sciences have already permeated much deeper lying layers of the population, fertilizing and stirring them up. To effect this change it is only necessary to give the intellectual creative forces of industry the necessary play for their full development and activity, and by means of a good patent law to make their work protected and recompensed.

Unfortunately it is not only material disadvantages which arise for Germany out of the want of protection of technical progress, it also promotes the already widely-spread unsolidity of German industry and injures the reputation of Germany abroad. It has produced by degrees amongst us in technical matters a view of right quite different from other countries, a different morality. Whilst in England, France, and even in America, it is considered dishonourable, or at least unbecoming, to make use of foreign inventions without the consent of the inventor; even if his right to protection is doubtful or does not exist, in Germany this is not only considered proper, but in many cases even meritorious. As a characteristic example in this direction, I only need cite that in Prussia itself technical state officials do not hesitate to deliver to other manufacturers as a pattern for imitation new mechanical apparatus or arrangements which are perfected by manufacturers with difficulty and expense, or to bring them into competition and to assign the execution to the lowest tenderer. They are even often obliged to do so by their instructions. In a similar direction those manufacturers frequently openly recommend their manufacture to us on this ground, that they imitate on principle only the most approved and most novel constructions of recognized important firms, and therefore can supply cheaper than these as they had to bear no expense of invention and trial. In other countries this would be considered as dishonourable; here even state officials do not hesitate to make the best use of such apparently advantageous offers. The natural consequence is, that this anomalous morality by degrees permeates from above downwards through the whole life of trade and commerce, that the endeavour to furnish what is new and better in industry occurs more seldom, that competition for cheapness alone is predominant, and German manufacture is everywhere despised as goods of slight value. The gratifying pride of the English

manufacturers, whom no prospect of gain would induce to provide goods with his mark which were not first class and would do honour to his firm, is unfortunately only in a few cases to be discovered amongst us.

It is not to be wondered at, that these circumstances are the cause that not only German goods but also German manufacturers are brought into discredit abroad. If one considers also the indignation which foreign inventors feel at the general refusal, and in any case insufficient protection of their inventions in Germany, which they consider, not as the consequence of a special economical theory, but as an intellectual pillage systematically carried on and promoted by the Government and the endeavour of the German abroad always to spy out foreign secrets of manufacture and contrivances which is there looked upon as a breach of confidence and dishonesty, the contempt of the German abroad with which one meets so often is explained. German honesty, of which we sing and speak much, has abroad only a bad sound to Germany's immeasurable harm. This dislike everywhere abroad to Germans and German ways has recently considerably increased. One rightly considers patents for inventions with the obligation of publicity as a work of economical freedom, which brings technical advance to the society of the nations practising industry, on the intensity of which at the present time the well-being of the people essentially depends, and from which alone a gradual increasing improvement of the social condition of mankind is to be expected. One might pardon a ruptured divided Germany seceding from this work like Switzerland and other small states, but not the powerfully founded German empire from which one demands a share in works and sacrifices commensurate with its importance, which the other nations impose upon themselves in the general interest of culture. Only when the German empire has taken its full share in this labour, only when the German nation has contributed to the increase of the store of mankind in knowledge and understanding corresponding to the powerful position of its state, and when Germans themselves have obtained again by honesty in trade and fitness for their work the full respect of other nations, will the world be reconciled to the great revolution which Germany's political resurrection has produced, and our fatherland be protected against all storms in the future. Promoting, recognizing, and protecting all good and useful intellectual creations, and in the first line protection of the industrial advance of all departments by a good patent law, reconciling the interests of the inventor with those of trade and the public, form the indispensable basis of that successful activity which can bring about these conditions. The society for the protection of patents has undertaken the promotion of such a rational patent law. The carrying of such a law would satisfy a want deeply felt in the industrial circles of the whole of Germany, and especially of the south of Germany, would provide the central point for all the endeavours directed to technical advance hitherto

wanting, and knit trade circles more firmly to the empire and its institutions. Even a well founded expectation of the speedy regulation of the question of protection for invention would at last act encouragingly and bring new life to many important branches of industry now hopelessly languishing, and spur them on to the utmost endeavours in order successfully to maintain the struggle for existence in the hope of better times coming during the present heavy commercial crisis, which, besides the unsound, destroys much that is sound and solid.

OFFER CONCERNING THE FOUNDATION OF AN INSTITUTE FOR THE EXPERIMENTAL PROMOTION OF THE EXACT SCIENCES AND OF HIGHER ENGINEERING.*

No country in the world has done so much for scientific and technical instruction as Germany, and especially Prussia. This is also recognized everywhere, and the German method of instruction serves as an example in all countries. In this Germany has, perhaps, done too much with respect only to its own material interests, for German scientists, and in still greater measure German engineers, are spread over the whole world, and intensify by their acknowledged ability the competition which foreign industry opposes to German industry. Moreover, the highly cultured scientists and engineers remaining at home find occupations corresponding only in a small degree with their knowledge. According to the number and culture of its scientists and engineers Germany without question should stand at the head of scientific and technical progress, even though the reasons why its industry has remained behind that of other nations are to be sought to a great extent in other directions. The reasons why this expectation has not in general been fulfilled lies evidently in the fact that both for scientific investigation, as well as for technical inventive work, the ground was not favourable for the forces existing in abundance. As regards engineering this unfavourable condition has decidedly improved since the passing of the German patent law. Since through it inventions are placed under real protection, inventors and manufacturers can bestow care and money on the thorough working out of new inventions in the often fallacious hope of great future

* (From the Memorial of a Commission summoned on the 11th June, 1883, for considering the Organisation of a Physico-Mechanical Institute.) 1883.

profit, for the competitor is no longer, as formerly, equally entitled to employ it without being burdened with previous troublesome labour and expense. There is certainly no doubt that the manifest impulse to German industry in latter years is due to the action of the now existing protection for patents. Inventions and improvements are no longer introduced abroad as formerly, where they received patent protection to the great disadvantage of German industry, which thereby everywhere lost the initiative, and had to be satisfied with imitation and lost more and more its consideration in the world. However pleasing may be the impulse which German industry has thereby received that it has become in many directions equal with foreign industry, and in many branches has even taken the lead, yet this development conceals great dangers for it, and will not alone give it the position due to it through the preponderating intelligence active in it. With the existence of patents the great difficulty prevails of determining what is an actual invention which introduces something actually new and what is only an adaptation of known devices and methods, which any practised technical person at once can bring into use when the problem is set him. It is therefore more and more the tendency in all countries without respect to this to patent all first uses even when they contain no real inventive thoughts. There is thus developed a heavy obstacle for the working industry which finds itself hemmed in by numberless patent claims in all directions without simultaneous increase of its technical aids. This danger can only be prevented by more powerful development of scientific research with simultaneously greater restriction of capability of patenting. Scientific research always forms the safe foundation of technical progress, and the industry of a country will never acquire a leading international position and be able to maintain itself if it does not at the same time stand at the head of scientific progress. To bring this about is the most effective means of raising industry. German science has always taken a prominent position. We shall also not go wrong if we assume that it is, thanks only to the high position of scientific culture in Germany, that German industry, notwithstanding its unfavourable position, has been able to maintain its place to a certain extent. On the other hand, however, it must be conceded that scientific progress among us does not yet by a long way correspond to the extent of our scientific culture. This appears all the more remarkable as Germany is also rich in highly gifted natural philosophers and as the German nation is not behind any other in the world in scientific endowment. This is manifestly to be traced back to a defect in our state arrangements. With us science is yet in the same condition in which engineering found itself before the introduction of protection for invention. The state has turned its whole strength with undoubted success to the advancement of scientific instruction. Its teaching establishments produce a great number of highly cultured natural philosophers whose life vocation is almost always again

tuition. Scientific investigation itself is nowhere a life vocation in the state organization, it is only a permitted private business of the learned besides their vocation, teaching business. Individual research stations, which are called forth by special urgent needs, and also the academies which are indeed dedicated to scientific investigation, but treated as inferior offices only and not provided with the necessary arrangements for carrying out experimental investigations do not essentially alter anything. The professional scientists of the academies are so entirely overloaded with learned occupations in addition to the instruction incumbent on them, that they, according to the expression of one of our first natural philosophers, must cease to be scientists. That notwithstanding this so many highly important and laborious scientific works have been produced by these heavily burdened German professors is a proof highly honourable to them of their all absorbing love of science. It must, however, be pointed out as a waste of national strength, that highly gifted enquirers, talents such as only seldom come to light, are heavily burdened with professional labours, which others would perhaps perform even better, and are thereby in great measure withdrawn from science itself, to which they would bear incalculable service if they could give themselves up entirely to it. But it is a still greater pity that so many talented and highly cultured young students find no opportunity to carry out scientific work. The laboratories of the universities and schools only remain open to them as a rule until they have completed their scientific training. These institutions are, indeed, intended and arranged for tuition, and are not suitable as a rule for more delicate and extensive scientific investigations. The unfortunate consequence in most cases is that scientific labours which would animate and fructify whole domains of life remain undone, and that, in the struggle for existence, talents do not develop or fall to the ground unrecognized, which under more favourable circumstances would have been able to perform great things to the honour and to the material advantage of the country. This is especially true as regards experimental physics. Chemistry stands in closer connection with industry, which holds out to many eminent chemists paying employment and opportunity for works of investigation. This is promoted by the circumstance that places and arrangements for chemical researches are much more easily set up than those necessary for extensive experimental physical researches. German chemical industry has therefore always been able to maintain itself at those scientific and technical heights which correspond to the German position of culture. Unfortunately this cannot be said of experimental physics. Here England has acquired a decided advantage by its wealth existing in wide circles and the predilection of Englishmen for scientific employment. Well-to-do Englishmen have erected private laboratories in great number in which they themselves work zealously and give an opportunity to able specialists for carrying out

great works; notwithstanding the proportionately much less extended scientific training in England, this country has yet on this account accomplished much and produced disproportionately many talents of the first rank. In recent times England, France, and America, the countries which are our most dangerous opponents in the competitive struggle, have recognized the great importance of scientific superiority for material interests, and have sought vigorously by the improvement of their tuition to raise scientific culture and to provide contrivances which promote scientific advancement. The characteristic perseverance of the Anglo-Saxon race and regardlessness in carrying out things which are recognized as useful and necessary, has already led to quite surprising results. France has always bestowed great care on scientific instruction. For the rest the circumstances in this country are the same as in ours. Although in France scientific instruction is well organized, and the knowledge of natural science widespread, and although in the Conservatoire des Arts et Métiers they possess an institute, which ought to serve principally for scientific technical research, it has yet been recently considered necessary to found a large new institute which is exclusively intended for scientific researches. It is therefore to be feared that the advantage that we still have up to the present, that of better organized scientific instruction and of more widely spread scientific culture, will soon be lost, and that we cannot maintain ourselves in the future at the head of scientific progress if it is not supported in our case also by state organizations. These organizations would have to fulfil a double purpose, to advance scientific enquiry generally and to aid industry by means of the solution of scientific technical problems and questions which are essential to its development. Laboratories would have to be constituted in connection with the universities and technical teaching institutions, which should be under the direction of highly gifted men, and which should be equipped with all aids to the fullest extent, so as to be able to carry out experimental investigations of all kinds with the greatest possible precision. Only specially fit and quite scientifically cultured persons should be employed for the work in these institutes, for carrying out determined researches that they had themselves proposed, or which would be made over to them for working at. In order to make clear the great importance which such an institute well supplied and liberally endowed would have for the development of industry a short retrospect of the history of this development is quite sufficient. We see this everywhere associated with certain persons and institutes, where it was possible by specially favourable conditions that scientific researches went hand-in-hand with their technical application. The scientific light, which in consequence illuminated and led technical combinations and methods, gave such institutions such a preponderance over others that the cost of experiments was not only covered by the higher commercial results, but also whole branches of industry were radically transformed by them, and new

ones of great importance created. As already instanced this combination of scientific investigation and technical use is much more easily realisable in chemical manufacture, and the rapid development of the chemical industry in Germany, and the important position which it still at present maintains in the world, is mainly due to this circumstance. Much more unfavourable is however the position of the trades depending on mechanical bases. Exact physical experiments demand much more costly instruments and specially prepared rooms; they are therefore much more expensive and lengthy, and require besides a much greater extent of knowledge and fitness of the men conducting the experiments. Such a coincidence of theory and practice favourable to progress will exist much more seldom therefore in branches of industry which rest on mechanical bases. If the state therefore confines itself as heretofore only to looking after instruction, the mechanical crafts necessarily lag behind the chemical in their development. Moreover it cannot be to the interest of the state to make technical progress too much dependent on certain specially favourably situated technical institutions. These disadvantages can only be avoided by the state taking care as far as organization is concerned, that experimental researches necessary for the rapid extension of the mechanico-physical branches of industry shall be accomplished by the most notable men with state means in the general interest and for the advantage of all. If our present position is considered, the convincing necessity for such an institute for investigation and enquiry organised by the state is perfectly obvious. Exact mechanics ten years ago had lost its superiority to a very considerable degree. The faults brought to light were so grave and evident that then the impulse was given for founding a state organization for supporting and raising home mechanics of precision by state institutions, which could no longer satisfy their need of instruments of precision at home. Since then a radical improvement has certainly taken place in this, but it will not again attain its former high position if the help then suggested is not actually given. It is a question of a long series of experimental researches on the constitution for the restoration methods of the different glasses necessary for optical, thermometric, electric, and other purposes, on their physical properties, and the exact determination of their constants. Similar highly necessary experimental enquiries are wanting on the properties of metals and their alloys, on the gradual alterations of these properties by external influences (alterations of temperature, concussions, electrical actions, etc.), on the co-efficients of elasticity and friction. Thorough researches are wanting on the specific conductivity of metals, on the specific inductive capacity of non-conductors and their specific insulation at different temperatures and with high electric tensions. All these enquiries and determinations are necessary for the successful development of trade activity resting on essentially mechanical bases. They can be performed neither in university nor in private laboratories as there is no place in

them for such extensive and tedious experiments, which neither bring direct profit nor special honour to those performing them. And yet much useless work and great loss of time and money would be avoided, if these experiments were carried out and were settled for the benefit of industry. In this way particularly also smaller works, which have not the means themselves of carrying out such experiments specially necessary for them, and can less easily incur losses through unsuitable choice of materials, would be quite substantially aided in the competitive struggles with the greater institutes possessing long experience. Even still more important consequences are to be expected from investigation proper, which would be connected with the institute previously planned for the elevation of the mechanics of precision. If one considers the progress of development of new branches of industry or such as are subject to radical transformation, one sees that it occurs usually by bounds. It begins as a rule in new scientific acquisitions by which new aims or new aids are given to industry. As an example in modern times it is only here necessary to mention the entire transformation of the whole science of heating by the regenerative system of heating, of the steel industry by the Bessemer process, the quite incalculable increase in value of the German iron fields (mostly phosphoric), by Thomas's dephosphorizing process, the manufacture of aniline and alizarine which has powerfully affected the international balance of trade of Germany to its advantage. The possibility of the cheap production of powerful electric currents by means of the dynamo machine will exert a similar transforming action on mechanical industry. To the rapidity of transmission of electrical effects which has already produced such a transformation in our cultured life, is now added the transmission of power in quantity by electricity and its re-application at other places to the most varied technical labours. Just in this case can be recognised without doubt the necessity of state organization for scientific experimental enquiries. Although the principle of the dynamo machine was already published in the Berlin Academy in January, 1867, and the great technical consequences hinted at, to which it would lead, more than a decade has passed before the activity of the industries of all countries succeeded in working out this principle so far that it could be used with advantage in practical life. Industry had not the time and means to carry through the numerous experiments necessary. Even now a number of unsolved scientific questions exist, which stand in the way of this development. The technical consequences ought certainly not to be undervalued which will result from the application of electric currents of any desired strength in the most varied branches of industry. The country which first realises them will thereby attain a great advantage over other countries. There are, therefore, important questions of political economy which depend on the state support of scientific advance in this department. It is to be added that owing to the application of electricity on a large scale the necessity has become

apparent of fixing determined electrical units for trade and of permanent arrangements for the control of the units coming into use. Although these units have been brought forward and rendered practicable in the first instance in Germany, an organization was wanting to carry out the laborious scientific work to completion necessary for practical application, and there is danger that here again England and France will gain precedence of us. Already this burning question of electric units of measurement makes the quickest possible foundation of an organization for scientific experimental research with suitable buildings and apparatus of such necessity that it cannot be refused. The necessary funds for carrying this out are hardly of consideration compared with the incalculable advantage which will arise from such a well-endowed organization furnished with necessary means.

ON THE IMPORTANCE AND THE OBJECTS OF THE PROPOSED PHYSICO-TECHNICAL STATE INSTITUTION.*

PREFACE.—After the establishment of a Prussian state institute for the furtherance of exact science and exact engineering already planned in the year 1872 was propounded in so essentially extended a form by a commission of the most illustrious scientists and technists called together in the year 1883, that the space set aside for the purpose in the newly established Charlottenburg Polytechnic was proved to be inadequate, Werner Siemens offered to the Royal Prussian Minister of Instruction the gift to the Prussian state of a site of 12,000 square metres on the condition that the latter would engage to erect, establish, and maintain the necessary laboratories and other buildings for the department of the projected institute to be entrusted with fundamental scientific investigations. Awaiting the approbation of the Prussian Diet, necessary for the completion of the arranged terms, he then announced that he would also bear the cost of erection of the necessary buildings, and in order that a whole building year might not be lost, would go on at his own risk, without asking from the Prussian state a guarantee to supply the means in the budget for 1885–86. According to his wish, the architectural adviser of the Royal Prussian Ministry of Instruction was empowered to assist him in the design and carrying out of the works.

* (From a Memorandum to the Reichstag regarding the establishment of a Physico-Technical State Institution for the experimental furtherance of exact natural philosophy and exact engineering.) 1884.

Affairs were in this position when Werner Siemens, having regard to the national importance of the plan and in the hope of carrying out the same in greater extent and with richer means, resolved to make to the Empire the offer already made to Prussia. The Prussian Minister of Instruction expressed his agreement herewith; his great wish was only that it might any how be possible to call into life the important institute.

Werner Siemens thereupon declared himself ready to make a donation of half a million marks in land or capital to the Empire for the purpose of founding an institute for carrying out natural science researches for technical purposes, and has brought together in what follows his opinion on the importance and the objects of such an institute.

State arrangements for the promotion of scientific progress are restricted in general to looking after scientific instruction. It might be said that, perhaps, they do too much in this. This is specially true of Germany, from whose celebrated educational institutions a number of highly educated young scientists issue who hardly ever find any other occupation in the service of the state and in private life than that of teaching, that is in the reproduction of the same species. For the development of science itself no organization exists, this is left to the private activity of the teachers in their leisure hours and to private persons skilled in science. Certainly academies exist in most countries whose duty it is to work for the development of science, but with few exceptions only scholars are nominated as academicians, the object of whose life is teaching, which demands the whole of their time and power. Hitherto Russia was the only exception to this; Russian academicians receive their pay as such and are not bound to educational activity. The Russian academy has also well endowed laboratories, in which the academicians can carry out scientific investigations. In fact in these laboratories almost all those investigations have been carried out which have given Russia an honourable place in science. That the results have not been more startling is easily explained by the position of Russian methods of education. If on the other hand, Germany, notwithstanding the total want of state arrangements for the investigations in question, has always taken an important position in natural science, and even in the unfortunate period of its political impotence and division maintained honourably the German name, this is pre-eminently due to its educational institutes and to the love of science of the German scholar developed and maintained by them.

Formerly this was sufficient when the extent of scientific knowledge was still small, and important researches could be carried out with simple arrangements at small cost. In recent times, however, this has been entirely changed. The deeper science has dived into the secret arrangement of the forces of nature, the more

difficult have become the problems to be solved, the clearer must be the methods of proof, the more exact must be the measurements and weighings by which nature itself replies to the inquirer according to the law governing it. For the solution of decisive scientific experiments, are now required specially fitted, well situated places protected from external disturbances, excellent and costly instruments, and the complete sacrifice to the problem undertaken of the scientist equipped with all knowledge. For this purpose the lecture rooms and laboratories of the universities and scholastic institutions devoted to the purposes of teaching as well as the professors employed there do not suffice. These are always so much the more over-burdened with their office of instructor and the other duties connected with it, the more capable they are, and the more they have shewn themselves to be pioneering enquirers. The requisite locale and the means of procuring the necessary instruments and apparatus also fail them as well as the leisure for the mental grasping of their problems of enquiry. The result of this is that the most important problems remain unsolved, and that highly cultured men, who could by their research work benefit their fatherland and mankind generally by priceless services are engaged in the service of education, which less gifted men could perhaps accomplish more successfully.

A very striking example how detrimental this entire want of state arrangements for the experimental investigation is for our fatherland, is shewn among others by the international negotiations for fixing electric units of measurement. Although these units were theoretically brought forward and verified in Germany, yet the difficult and expensive labours for their exact reproduction could not be carried out in Germany. It was the private laboratories of rich England which undertook the work. Also the summons addressed to the government on behalf of the international commission for fixing electrical units to support the work of their learned men in this direction, could lead among us to no decided result, for in the whole German empire no place existed suitable for these measurements with the necessary apparatus. In Germany the class of rich scientific dilettanti is wanting, which has already done so much in England, and has raised England's scientific fame high above the measure of its average culture. Amongst us there are only certain large industrial establishments which were fitted and prompted by their own necessities to undertake such costly and comprehensive public works. But factories are only in certain cases suitable for exact work.

These considerations long ago determined the undersigned to make over to the existing Royal Academy of Science of this town by a testamentary legacy a large sum of money for the foundation of a laboratory which should be dedicated to scientific fundamental investigations. When, however, in the past year, on the occasion of commissary advice on the organization of a technical research institute to be established in the rooms of the Royal Polytechnic,

the accentuated necessity for a similar research institute serving exclusively for scientific investigation was recognized by his Excellency the Minister, Dr. von Gossler, but for its accomplishment, besides financial considerations, there entered the difficulty of obtaining a suitable site, I solicited to be allowed to place at the disposal of the state such a site thoroughly suitable of about one hectare area lying in the Marchstrasse, in Charlottenburg, on the condition that the State, at its cost, would build upon it for the purpose in question, and would suitably endow the institute. I further offered myself to carry out the construction of the laboratories in the hope of thus preventing further loss of time.

Although by the warm interest which the Minister, von Gossler, took in the fulfilment of the proposed building the hope that the financial difficulties still existing would be overcome appeared well-founded, yet I could not fail to recognise that the plan in this way cannot be carried out to the extent which would correspond to its importance and to the contribution of about half-a-million marks which I am ready to expend for its realization. It is a question of a state arrangement which will be of use to the whole empire in the same measure as to the individual state. To the empire there would accrue material as well as ideal advantages of great importance from a natural science laboratory as proposed. In the competitive struggle of the people now so actively carried on, that country has a decided preponderance which first sets foot upon new paths and first starts the branches of industry based on them. Almost without exception it is new scientific discoveries, often of very insignificant kind, which open out such paths and create important branches of industry or animate them anew. Whether the discovery of a new scientific fact is technically applicable, is, as a rule, only found out after completely and systematically investigating it, that is to say, often only after a long time. Therefore scientific progress must not be made dependent on material interests. Modern culture depends on the dominion of mankind over the forces of nature, and every newly discovered law of nature increases this dominion, and thereby the highest good of our kind. Since by the patent law the property in invention is protected in the German empire and by German educational institutions, scientific and technical culture are widely extended, the power and means are not wanting for the technical application of scientific discoveries. The encouragement of scientific investigation is therefore in an eminent degree a promotion of the material interests of the country. This fact, which is not always understood, is probably the chief reason why scientific discovery confers everywhere high honour on the country where it originates. Not scientific culture but scientific performance assigns to a nation the place of honour among cultured people. It appears therefore to be the duty of the empire and not of the individual states to make the necessary arrangements to bring the scientific performance to that height and

keep it there, which corresponds to the average scientific culture of the country.

I remark, finally, that with the offer of a contribution of half-a-million marks in land or capital for the foundation of the proposed institute, I have in my mind only the aim of being of service to my fatherland and of showing my love of science, which I have to thank exclusively for my success in life.

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THE END.

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